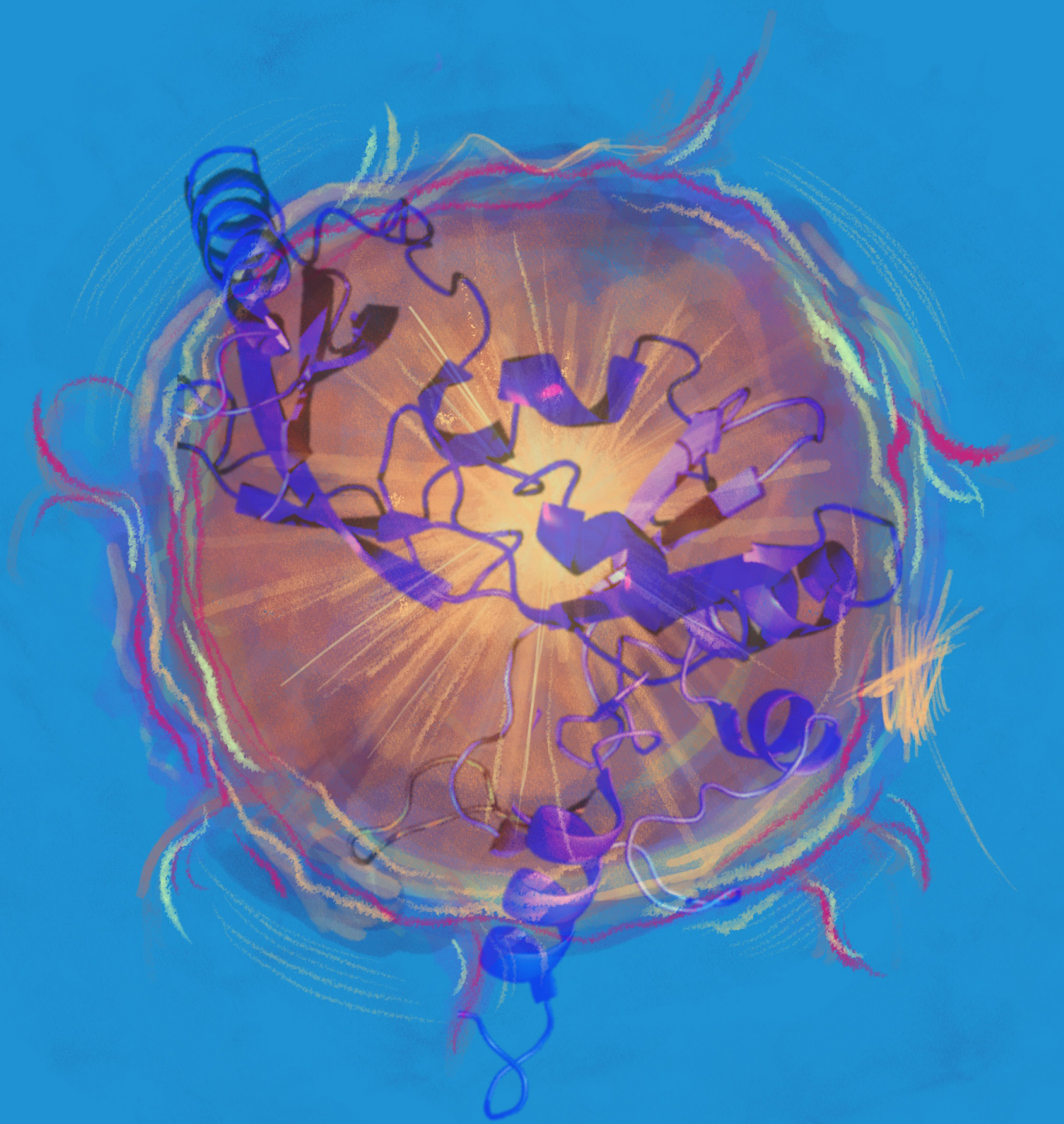
MUSCULOSKELETAL MATTERS

SPRING 2023



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In this issue:

STEPS IN THE RIGHT DIRECTION? HOW RECENT CHANGES IMPACT THE RESIDENCY MATCH

ARA KHOYLYAN

Dr. Kenneth Koury is a board-certified and fellowship-trained **orthopaedic trauma surgeon** in Northeast Pennsylvania. He obtained his medical degree from Pennsylvania State University and completed his residency as well as his fellowship in orthopaedic trauma and adult reconstruction at Rutgers, the State University of New Jersey. In addition to his many responsibilities as an orthopaedic surgeon, he also serves as the program director of the Geisinger Northeast Orthopaedic Surgery Residency and of Orthopedic Trauma at Geisinger Wyoming Valley.

I had the special opportunity to shadow Dr. Koury during one of his busy clinic days, and he was kind enough to offer some of his valuable time answering questions about how he approaches residency candidate selection. In addition to discovering his perspective on standardized metrics such as the Step exams, I was happy to additionally learn about the intricacies of a young orthopedic surgery program in the process of establishing its identity.

How do you anticipate that Step 1 transitioning to pass/fail will impact your selection process?

While most candidates this cycle had numerical Step 1 scores, I certainly placed less of an emphasis on Step 1 anticipating the changes moving forward. However, another large contributor to this adjustment in decision-making was the introduction of signaling to the application process.

What is "signaling" and how did this new tool impact candidate selection?

Each candidate can now signal 30 different programs, identifying them as programs that they are very interested in. Given that we had more signals this year than we could interview, I did not need to do a deep dive on the entire applicant pool. As a result, I did not need to stratify based on measurable attributes, which is what Step 1 has typically been used for. The addition of signaling allowed us to break down the applicant pool into a much more manageable number, fulfilling the role that cutoff Step scores have traditionally served. Signaling, in short, has tremendously helped focus attention on those applicants who are eager to join our program.

In your opinion, what role do measurable attributes such as Step scores have on evaluation the overall competence of a candidate?

I see myself using the Step scores less and less. I value a holistic approach and tend to look at candidates across the spectrum of Step scores with special considerations of other important factors, especially with the introduction of signaling. However, I still value having evidence of success on standardized tests, understanding that residents need to pass their formal licensing exam at the end of their training. Overall, my general approach and viewpoint does tend to differ from the more established residency programs elsewhere, who have traditionally relied heavily on Step scores with cutoffs.

Did Step scores play a role at all, then, in your selection of candidates?

There are many factors that we consider when selecting candidates for interviews. These factors combine to produce an overall evaluation of each candidate. In one iteration of evaluating candidates, among the many other factors, I considered the average of Step 1 and Step 2 scores. In another, I considered only Step 2 scores. In the final iteration, I did not use Step scores at all to evaluate the candidates. Ultimately, each iteration produced a very similar pool of candidates to be selected for interviews, so I ended up not using Step scores at all. Finally, once a candidate has been selected for an interview, Step scores are no longer a factor to be considered. I imagine that some programs will have many more signals than positions available for interview, so the Step score will continue to play an important role.

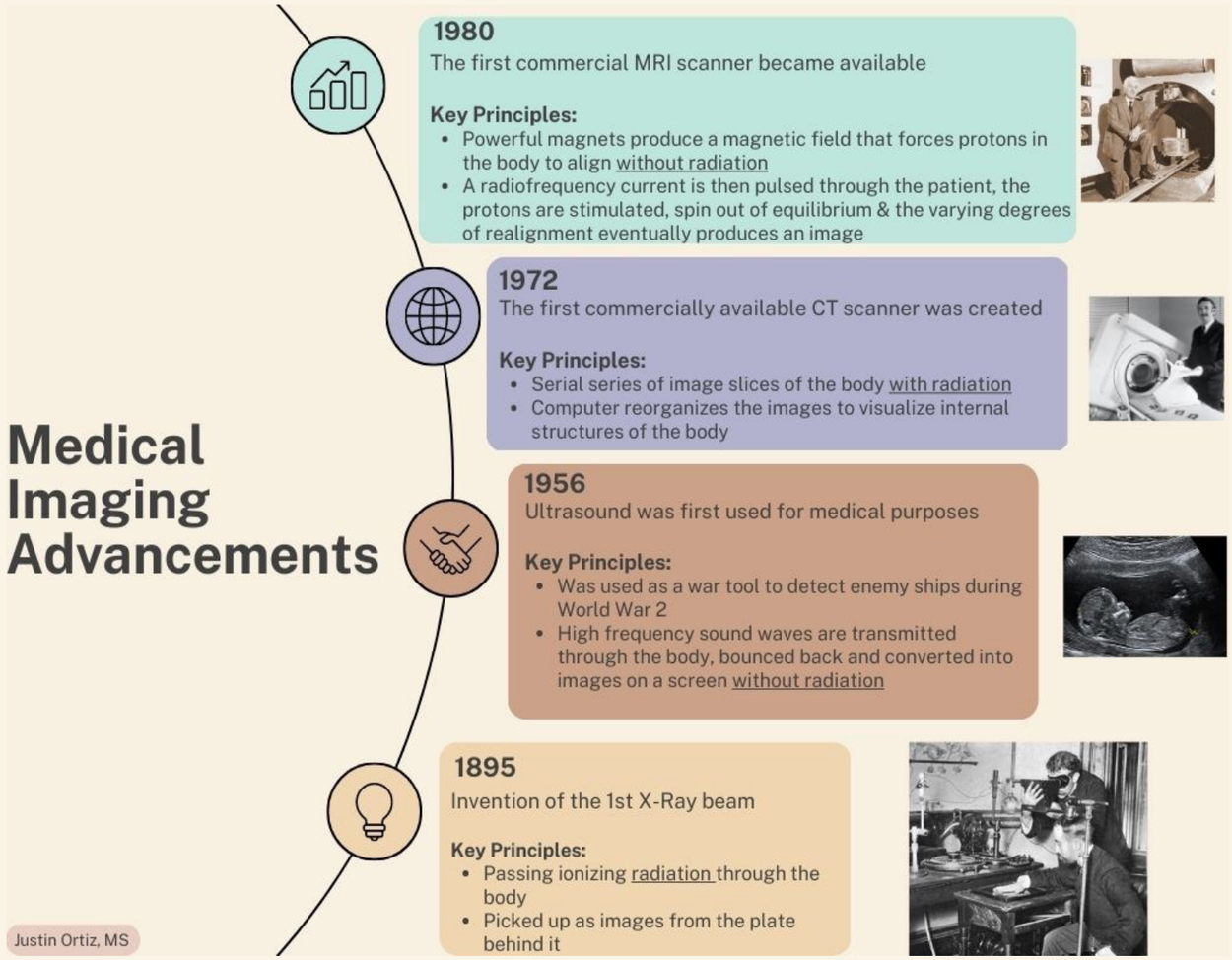
What are some challenges that you are facing as a newer residency program?

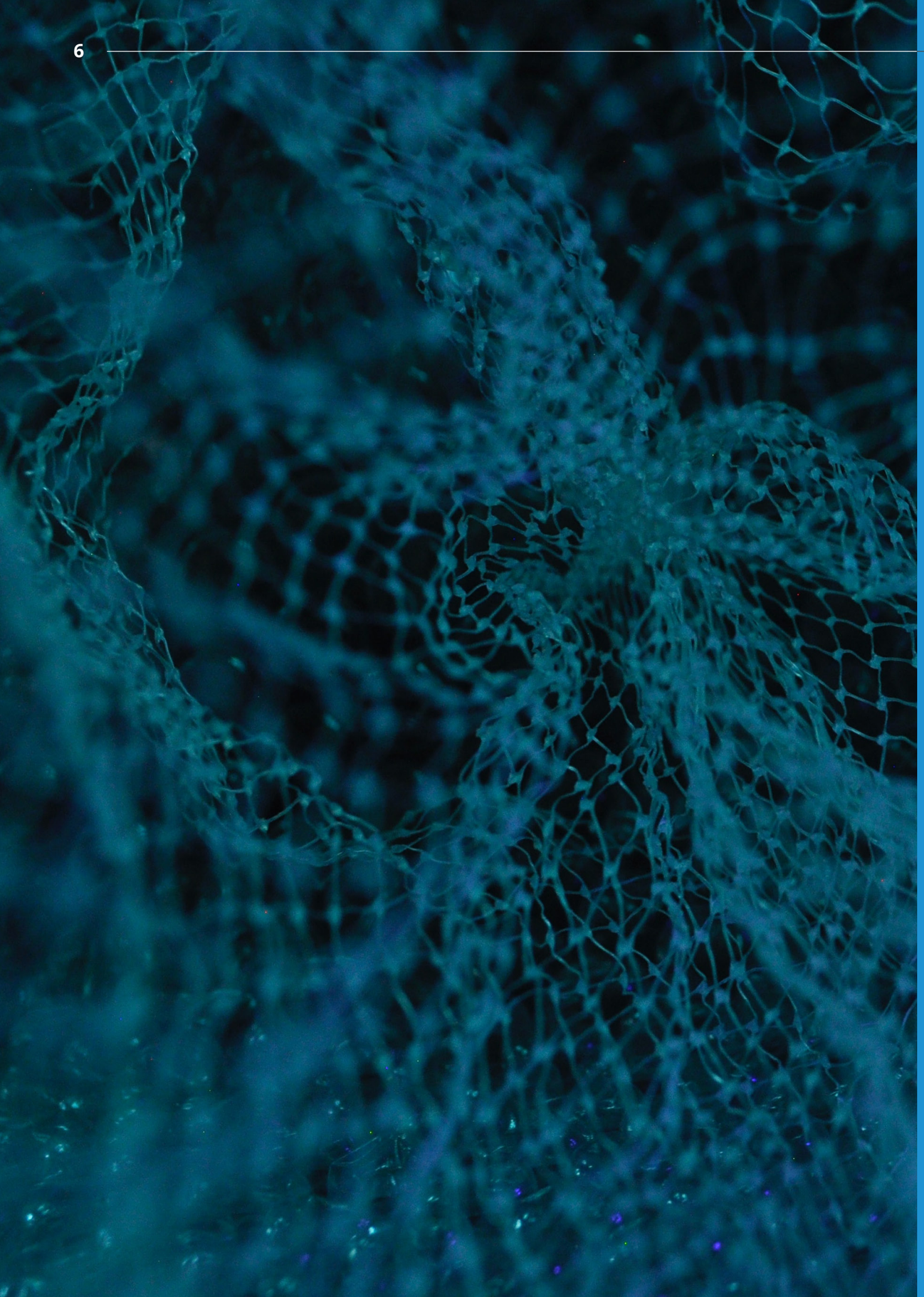
The initial stages are challenging because we are still in the process of establishing our personality. We don't have many residents yet to completely understand who will work well together. For this reason, we highly value students who have visited and rotated at our site – this allows us to make sure that the candidate fits appropriately within our program.

Can you discuss some of those major factors that you consider when reviewing candidate profiles?

The process now starts with us looking at the candidates that have sent a signal. Among those candidates, we make sure that we are ultimately interviewing people who represent the entire spectrum of the applicant pool. Orthopaedics is not known to be a classically diverse field and I value the importance of adequately representing diversity in our program. This is, of course, limited by the candidates that do decide to apply here. I also strongly consider the applicant's interest and attachment to our setting and region, which is a combination of urban and rural. This is an important factor when deciding how well an applicant matches with the identity of the program. Of course, letters of recommendation are very important, namely from people whom I am familiar with. I also emphasize clerkship grades if available – while I know it is not practical to "honor" every clerkship and it is challenging to assess grades given that every school evaluates differently, I do like to see students who worked hard to honor or high pass even the clerkship fields that they were not planning to ultimately pursue. I also factor in whether students rotated at our program – rotating here allows us to establish close interactions and learn much more about the students. Research and extracurricular involvements certainly play an important role as well. While there is no concrete cutoff for research volume for us, I do think it is important that students get involved with the field in this capacity. The personal statement can certainly help when there is a profound story to be conveyed and rarely does it hurt a candidate. Ultimately, there is no magic bullet for success, and I don't think there should be. These factors add up to create a composite picture of the candidate that can then be evaluated for appropriate fitness with the program.

I am grateful for the time I spent with Dr. Koury discussing his approach to candidate selection. It was an insightful conversation that elucidated the changes brought forth by signaling, the value of measurable factors such as Step scores moving forward, and the differences between newer and more established programs. Most of all, it was exciting to discover that these recent changes may provide applicants greater opportunities to pursue the programs or specialties that interest them most. Are these gradual steps in the right direction, towards a more holistic approach? Only time will tell, but our conversation certainly left me hopeful.





STRONGER TOGETHER: THE VITAL ROLE OF EXERCISE AND SOCIAL SUPPORT IN MANAGING MULTIPLE SCLEROSIS

JOSHUA ELMORE

MS (multiple sclerosis) is a neurological ailment that impacts roughly 1 in every 1000 adults in the United States[1]. The disease displays a range of symptoms, including depression, which is prevalent in patients with MS[2]. Studies have shown that the frequency of depressive symptoms and major depressive disorder is higher in individuals with MS than in the general population3. People with MS who suffer from depression also have poorer cognitive function and quality of life than those who do not4. Depression is a risk factor for morbidity in MS patients, emphasizing the importance of identifying factors that may influence this mood disorder[5]. Several studies have linked physical activity and social support to depressive symptoms in people with MS illustrating their importance in disease progression.

Additional factors, such as perceived stress and mobility disability, may play a role in the relationship between physical activity, social support, and depressive symptoms[6]. Studies have shown that physical activity and social support are linked to lower levels of mobility disability in people with MS. Mobility disability, in turn, has been associated with higher rates of depressive symptoms[7]. Physical activity and social support have also been linked to lower levels of perceived stress, though not specifically in MS patients[1]. Perceived stress, on the other hand, has been positively associated with increased severity of depressive symptoms[8]. Taken together, these findings suggest that physical activity and social support may be linked to depressive symptoms through their impact on reducing mobility disability and perceived stress, which may act as mediators.

The Department of Kinesiology and Community Health at the University of Illinois conducted a study which included 218 individuals with MS with 197 being women and 21 being men. This study's innovative discoveries include (1) the independent and significant correlation between physical activity, social support, and depressive symptoms, and (2) the identification of mobility disability and perceived stress as mediators of the relationship between physical activity, social support, and depressive symptoms[9]. Ultimately, they established that consistent physical activity may lead to a reduction in depressive symptoms by decreasing mobility disability and perceived stress.

Previous research has linked low physical activity levels and insufficient social support to more severe or frequent depressive symptoms in people with MS[10,11]. Furthermore, current research shows that both physical activity and social support have independent and statistically significant associations with depressive symptoms, and that these associations are mediated by mobility disability and perceived stress in people with MS9. The present study's discoveries represent a breakthrough and push the envelope of previous research on the correlation among physical activity, social support, and depressive symptoms in MS. It is worth mentioning that the autonomous connections between physical activity and social support with depressive symptoms correspond with other research that posits that these factors are also autonomously related to self-efficacy, functional limitations, and quality of life in individuals diagnosed with MS[10,11,12]. Taken together, these findings suggest that physical activity and social support should be considered as distinct yet complementary targets for managing depressive symptoms, and potentially other outcomes, in people with MS.

The association between physical activity and depression in persons with MS has been observed previously, with some evidence suggesting that this relationship may be mediated by mobility disability[9,13]. Additionally, when comparing a different study, there was an association between physical activity and depressive symptoms, and the researchers identified mobility disability and perceived stress as two mediators of this relationship[9]. This clinical correlation between existing research clearly outlines the importance of physical activity in the role of managing MS.

Similarly, social support has been linked to reduced perceived stress in previous research, and perceived stress has been strongly associated with depression and depressive symptoms in MS[14,15,16,17]. Consistent with this, it was found that lower levels of social support were associated with more frequent depressive symptoms, and that this relationship was mediated by increased perceptions of stress[9]. Importantly, though, it was discovered that there is an independent association between social support and depression, beyond the influence of physical activity9. This clarifies the need for both exercise and social support when managing depressive symptoms in patients with MS.

Ultimately, past and current research provides evidence that physical activity and social support are inversely associated with depressive symptoms through the mediation of mobility disability and perceived stress in individuals with MS. Researchers and clinicians should consider incorporating physical activity and social support interventions in managing depressive symptoms in MS, given the independent and complementary associations between physical activity, social support, and depressive symptoms.

MY REMINDER

MARISA VANNESS

My father is the sort of person who dyes his white hair a vibrant purple to be, "cool and youthful." He makes up words and chants for fun (which I found out, to my embarrassment, after using these chants in my college admissions essay). He becomes instant best friends with any gas station attendant he's ever met. His hair and his eyes haven't changed from when he was young enough to teach my brother and I "two-hand touch" football, when he actually was cool and youthful. You need to know this about my father.

When I see his face now, everything else is still a shock. When my dad sends a picture of himself standing in front of the forest-covered mountains behind our house, I feel a sucker punch.

I remember climbing on his shoulders at bonfires on star-filled nights, sparks flying past my head. I remember sunny summer days spent planting Christmas trees on mossy banks of our creek that we could cut down together to decorate when they were bigger. He helped me learn to check my car's oil so I could drive safely and would wiggle under the jalopies that he bought while explaining how pistons worked as if they were the most exciting thing you would ever see.

All of that is only possible when your body does not revolt against you. When aging has not made your body your enemy and filled your face with lines. How can anyone bear to age, except that we all must? You would think that a personality so infectiously charming and indomitable, despite some intense challenges, would never be held back, until one day, you see it is.

That holding impacts so many things.

Whenever I used to visit my parents' home, my family would go on our favorite hike. My dad insisted he wanted to come, though he had been struggling to go for longer walks for months at this point. With each struggle, you could see him getting more withdrawn and upset. You could see time weighing him down. Was it worse to try and fail or to stay at home? This time, he had rested, he assured us. He waved my sister and me ahead and picked out a walking stick for himself, telling us how lucky we were to live here.

My sister and I spotted newts and sent them scurrying safely across the path. We were in thrall to the crimson and coral hues of the leaves scattered amongst the pine trees on the endless mountains ranging before us. The late fall sunlight kept us just on the edge of being warm, while the crisp fall air kept us from standing still too long and waiting for our father. We did not notice how far he'd fallen behind until he shouted to us for help.

Growing up, my father was raised in the sort of family where he helped but did not need help himself. Hearing him shout for us brought us rushing.
He waited for us. He stared and tried to laugh but couldn't.
I took an arm and slung it over my shoulders, and my sister took his walking stick and set it down in the tall grass. The wind buffeted us, and the grass bent over as we carried my father down the mountain. We arrived back to flat land, breathless.
My father said thank you while shaking his head at the ridiculousness of it.

The next week, he told us he'd made an appointment for double knee replacements.

I wish that I could say the knee replacements were a magical cure. When you forget how hard it can be to get better, how hard it can be to heal, it becomes an impossible task to remember how to try. It feels good enough that you moved at all, let alone that you used to move ten times more than that, or that the whole point was so that you wouldn't be trapped inside all day. Whereas before he didn't want to be told not to do things, now my father cannot be told to do them. Somewhere along his journey of healing his body, he was not warned or did not think to question the toll that it would take on his mind.

Doctors, who can do such wonderful things, who can give people another lease on life through surgery- I appeal to you. We need you to see if your patient needs something more or different beyond the usual strong pain medication and physical therapy which are not always covered by insurance. Because even seemingly driven people do not always have the resilience they need to get back up when they've fallen. Those patients need doctors to listen when their wife is concerned that it will be too much or that maybe a drug like that could be bad with their history. We need doctors to see when they've started talking more slowly and have weight changes and are listless. We need doctors to know when something more is wrong, so that medicine doesn't make it worse in the quest to improve.

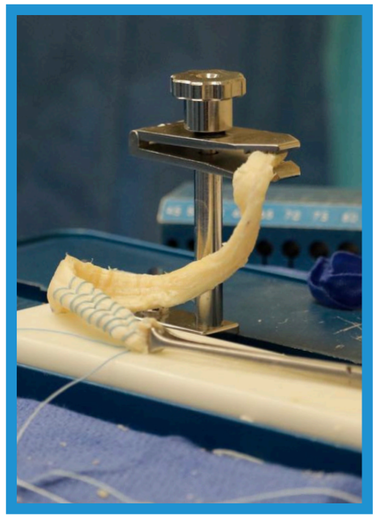
My father is still on his own path to healing, though certain parts of him will never be as he once was. He will probably never run around after his grandchildren, but I know how much warmth he still has and how much he wants to be with us for as long as he can. He still gives the most engulfing hugs and handshakes you have ever felt, and if a good Penn State game is on, you can still hear him chanting.

THE PREVALENCE OF ***ANTERIOR CRUCIATE LIGAMENT*** TEARS IN MALE VS FEMALE RUNNERS

KIELY CURRAN, MAGGIE WRIGHT, LIA SMERINA,
ROODY JOSEPH, PT, DPT, OCS

Background: The anterior cruciate ligament (ACL) is a critical structure in knee-stabilization that has the primary role in preventing anterior displacement of the tibia on the femur. Tearing of this ligament requires either operative or non-operative management, followed by extensive rehabilitation. This injury could leave an athlete out of play for over 6 months. Although ACL tears are most commonly presented in high-impact, pivoting sports, such as football, they are not completely absent in low-contact sports, such as running. An ACL tear could be devastating to both the runner's career- professional or leisure- and potentially have negative impacts on their mental health, consequently. It is critical to evaluate the predisposed populations and potential etiologies to ACL tears in order to target these populations with extensive, appropriate, preventative care.

Objectives: The goals of this review were to (1) identify the prevalence of anterior cruciate ligament (ACL) tears in females versus male runners and to (2) identify potential etiologies of ACL tears.



Methods: A systematic search identified studies regarding nutritional markers among trauma patients. All data was obtained using published peer-reviewed journal articles from PubMed using the keywords, "ACL tears + male versus female" and "ACL tears + gender + runners". The data included articles published between 2013-2023 including runners ages 17-50 years old. The data excluded articles published before 2013 regarding non-runners ages 0-16 or 51+ years old.

Results: Upon reviewing 644 articles and including 104 articles, it is evident that ACL tears are more common in females versus male athletes that focus on running. Numerous studies have attempted to assess potential etiologies leading to the difference in prevalence of ACL tears in males versus female athletes. These speculations include anatomic differences, joint laxity, hormone, and training technique differences, but there is not one agreed factor leading to this discrepancy.

Conclusions: An ACL injury or tear is the overstretching or tear of the anterior cruciate ligament in the knee. This injury has detrimental impacts on an athlete's career since it requires rigorous rehabilitation. Upon thorough review, it was found that ACL tears are more common in female athletes versus male athletes that focus on running. More research is needed to clarify the etiology leading to the difference in prevalence of ACL tears between sex in order to implement rigorous preventative measures to mitigate the prevalence of ACL tears in the female runner.

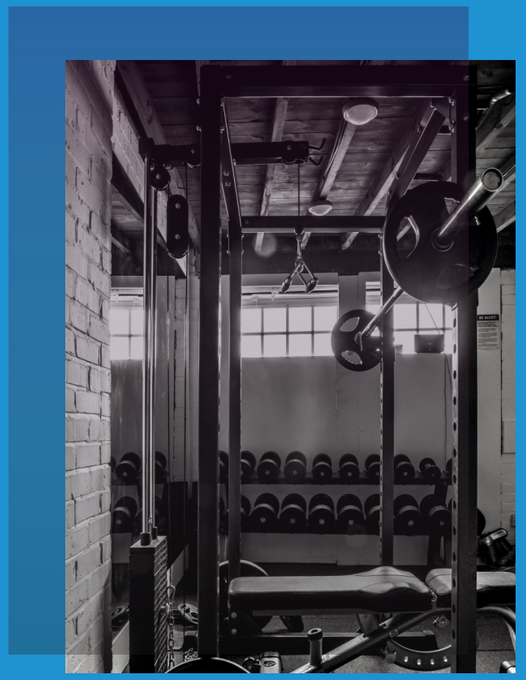
HOW HIGH INTENSITY INTERVAL TRAINING (HIIT) MAY BE STALLING YOUR GAINS

CEILIA SEVERINI

High Intensity Interval Training (HIIT) is a popular form of training defined by Harvard University as a "type of interval training which incorporates several rounds that alternate between several minutes of high intensity movements to significantly increase the heart rate to at least 80% of one's maximum heart rate, followed by short periods of low intensity movements." In the 1950s, interval training was first introduced as a higher intensity form of training, specifically targeted toward elite Olympic athletes to help them reach 100% of their maximum heart rate and improve their overall performance.

Today, however, HIIT is targeted toward anyone and everyone. There are many different types of HIIT classes out there today, including Orangetheory Fitness, F45 Training, Barry's Bootcamp, and more. HIIT training is an effective style of working out with many benefits, which contribute to its popularity. Some of these benefits include burning a lot of calories in a short amount of time. One study looked at the calories burned during 30 minutes each of HIIT, weight training, running, and biking. The study found that HIIT burned 25-30% more calories than the other forms of exercise[1]. A repetition for the HIIT workout within the study consisted of 20 seconds of maximal effort followed by rest for 40 seconds. Thus, the participants were working out for one-third of the time that the running and biking groups were. It is fairly common that HIIT workouts take less time than other workouts because they allow participants to burn more calories in less time. HIIT also has the ability to increase metabolic rate for hours post exercise [2,3].

HIIT has other benefits, including being one of the most effective ways for people who are overweight or obese to lose weight and for others, it is an effective way to gain muscle[4, 5]. The muscle mass occurs primarily in the muscle groups being used the most, usually the trunk and legs[6]. Although HIIT can improve muscle mass gain in some individuals, it usually does not show higher muscle mass in those who are already active[7]. Another study elucidated that HIIT can improve oxygen consumption[8]. Finally, HIIT has other important health benefits, including reducing heart rate, blood pressure, and blood sugar[9,10].



All of these benefits sound outstanding. So, why would HIIT be stalling your gains? Moderation is key for most things. Too much of a good thing can be detrimental. A study conducted showed that participants doing HIIT training almost everyday developed severe declines in mitochondria out of nowhere and showed signs of blood sugar dysfunction[11]. Once they decreased their amount of days doing HIIT training, their metabolic issues started to reverse. The takeaway message from the study, which involved 11 healthy, active men and women, was that HIIT training should not be done excessively if the desired outcome is health[11]. Although the participants in the study were not athletes and the study's focus was not on athletic performance, researchers say that adding many, intense interval workouts with little rest in between to the exercise schedule of athletes could be a tipping point toward performance and metabolic slip. This study was on the small side, but it shows promising results that HIIT is like many other things, best in moderation.

POURING YOUR GAINS DOWN THE DRAIN: THE LINK BETWEEN ALCOHOL AND MUSCLE PROTEIN SYNTHESIS

JOSHUA ELMORE

The ingestion of alcohol throughout human history has been part of various cultures for centuries and remains a popular social activity in many parts of the world. Nevertheless, research has elucidated that consistent alcohol consumption can have undesirable effects on various aspects of health, including muscle growth and protein synthesis[2,3,4].

Muscle tissue is in a continuous stage of construction and collapse, and the balance between these two processes are fundamental for sustaining muscle mass and function. Protein synthesis involves the creation of new proteins, and it is an imperative part of muscle growth and repair[1]. However, research has shown that alcohol consumption can interrupt protein synthesis rates in striated muscle, leading to dwindling muscle growth and decreased recovery from exercise-induced muscle damage[3].

One pathway as to how alcohol can disrupt protein synthesis is by obstructing the signals that initiation the process. Particularly, alcohol has been demonstrated to reduce the activation of the mammalian target of rapamycin (mTOR) signaling pathway, which is crucial for starting the process of protein synthesis in response to muscle damage or exercise[1]. Furthermore, alcohol consumption has demonstrated a reduction of insulin sensitivity, further inhibiting protein synthesis by the impaired uptake of glucose and amino acids into muscle cells[1].

Alternatively, alcohol can increase the breakdown of protein, affecting muscle growth and protein synthesis. Research has established that acute alcohol intoxication potentially leads to increase in protein breakdown rates in skeletal muscle, theoretically exacerbating the negative effects on protein synthesis rates[3]. Correspondingly, pathological transformations in skeletal muscle have indicated chronic alcohol consumption as a principal offender, including increased levels of muscle protein collapse and decreased muscle protein synthesis[2].

Overall, the currently available data propose that regular alcohol consumption has the potential to significantly affect muscle growth and protein synthesis in a negative way. Various mechanisms can generate this response, including the increase in protein breakdown rates and the disruption of signaling pathways that initiate protein synthesis. Additionally, pathological changes in skeletal muscle, as described above, due to chronic alcohol consumption can further impair muscle function and recovery.

However, while discussing the negative effects of alcohol consumption on muscle growth and protein synthesis, it is imperative to note that these changes may be influenced by various factors, featuring the amount and frequency of alcohol consumption, as well as individual differences in genetics, age, and other lifestyle factors. To illustrate, some studies have suggested that moderate alcohol consumption may not have significant negative effects on muscle growth and function[1]. Nevertheless, current inclusive evidence suggests that consistent substantial alcohol consumption is probable in its ability to have negative effects on muscle health.

In conclusion, alcohol consumption can have negative effects on muscle growth and protein synthesis, possibly disrupting muscle recovery and function. Breakdown rates and the disturbance of signaling pathways are some of the numerous mechanisms by which these results can occur. Consequently, people who participate in consistent alcohol consumption should be made aware of these conceivable negative outcomes in regard to muscle health and may want to consider reducing their alcohol intake to preserve optimal muscle function and recovery.

FROM THE SIDELINES TO THE OPERATING ROOM: AN INTERVIEW W/ DR. NIGEL WINSLOW SPARKS

NICHOLAS HAYNES

Dr. Nigel Winslow Sparks is a board-certified **orthopedic surgeon** practicing in Lewistown and Port Matilda, PA. He completed his medical school training at the Hahnemann School of Medicine in 1998. He then went on to complete an orthopedic surgery residency at Union Memorial Hospital Department of Orthopedics in Baltimore, MD, and a sports medicine fellowship at Doctor's Hospital UHZ Sports Medicine in Coral Gables, FL.

Dr. Sparks is a former member of the Canadian Olympic Soccer Team as well as the Toronto Blizzard and Philadelphia Freedom professional soccer teams. As the first member of his family to graduate high school, Dr. Sparks' story is one of **inspiration, insight, and wisdom**.

Tell me about your journey to medical school.

"I am the first in my family and extended family to graduate high school. My mom was a single mom with 4 kids. So, I spent most of my high school years in Toronto. We lived in government housing at the time. My mom says I was just born a different way. But I just always had a drive to sort of be better. I guess if you were to talk to a psychologist, they would probably say not having a father figure sort of pushed me in always looking for success. So, I tended to be really motivated, and I always got good grades. I've always been very athletic though, so I spent my high school career as a four-sport athlete but soccer was my main sport. I played well in high school for the youth national team. But because I was really good at school and coming from a family where most people don't get a good education, my mom really pushed me towards the academic side of it as opposed to the athletic side. She's said you need to do something with the school thing. We didn't have much money, and even though it didn't cost a lot to go to College in Canada, I just figured I'm really good at sports, so I'll just get a sports scholarship. So, I headed down this path of using sports to further my academics."

Dr. Sparks then went on to get a scholarship to Penn State to play soccer, where he not only excelled athletically but also academically. He continued this path of both academic and athletic excellence until he was eventually accepted to medical school.

Why orthopedic surgery?

"So, when I was at Penn State in my last two years, I was training and playing with the Canadian Olympic team and was always traveling. I had a couple of conversations with the orthopedic surgeon for the national team at the time and saw that he got to travel with the teams and still do what he wants. I was already headed towards medical school and thought I can do this orthopedic thing. So, that sort of pushed me towards it. You know, it's kind of funny how things worked out because it was just a natural fit for me. I had always been around sports and near the injury side of it and had a little bit of understanding of anatomy from reading so I thought if I'm going to specialize, orthopedic sports medicine obviously came to the top of the list."

Previously, you were the team physician for the Seattle Sounders, Jacksonville Jaguars, and Jacksonville Giants. Could you tell me about those experiences and how you ended up in your current position?

"It is a true privilege to be a team physician for a professional sports team; like, those jobs do not come up very often and they tend to be grandfathered in, where the person who takes care of the team is retiring and passes it on to someone else. It's not like you just wake up one morning and are like oh, I'm going to take care of this pro-team. So, early on I went through a number of practices, and I really wanted to do the sports medicine thing, but private practice just wasn't taking me anywhere far. So, I really wanted to get back into teaching and so I took a job with University of Florida. When I joined the University of Florida, I picked up a couple teams. So, when I got there to develop the sports program for the residents, I picked up the Jacksonville Giants, which was an ABA basketball team. And then I picked up the Suns which was the farm team for the Marlins baseball team. And then we picked up one of the prestigious high schools in town. So, I was developing this program and really trying to get involved in sports at a higher level. I think my background is a little bit unique in the fact that once you've been a professional athlete you've played at that higher tier, and it gave me an understanding. The private practice in town was the Jacksonville Orthopedic Institute. Their head was the team physician for the Jacksonville Jaguars. He asked me to help."

Dr. Sparks continued his career as the team physician, traveling with the teams for their games for 15 years, before transitioning to his current position.

"After doing that for 15 years my time was very constrained, you know I was always traveling with the team and my practice was really busy at the time and so I spent a lot of time away from home on weekends. So, we talk about physician burnout and all the different variables that play into physician burnout, and for me it was like, I'm going to have to take a step back. And I knew that my kids were getting older and starting to play sports and be active and I wanted to be available every weekend. So, I had the opportunity right after COVID to sort of come back to the East Coast from being in Seattle."

Are there any innovations or research being done in orthopedic surgery right now that you find to be particularly exciting, and if so, could you speak about those a bit?

"One of the real interesting sides of treating athletes is the mental side of it. It's hard to explain, but as an athlete you have a mental side of the game as well as a physical side. There's a lot of PTSD (post-traumatic stress disorder) in dealing with injuries when you go back to playing that can affect your play. There's a lot of tests that are coming out that can look at mental barriers."

Dr. Sparks then went on to express excitement regarding the potential future applications of virtual reality to improve mental health.

What general advice would you give to medical students?

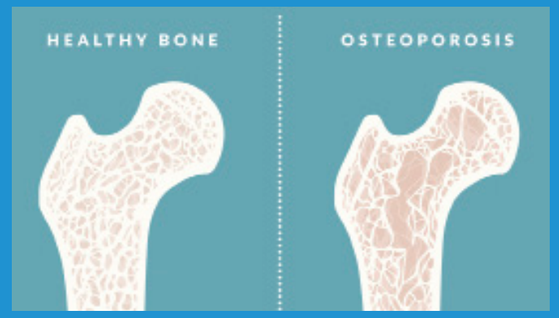
"I'm almost 20 years in now, and so much has changed with medicine even when I started. I remember when I was going to school and the ER doctor sort of gave me advice that doesn't even apply right now. So, the landscape is always changing in medicine."

Dr. Sparks went on to describe that a big challenge right now is "how do you maintain that personal feel with the patient where that patient feels like they are number one? That patient is not a number; that patient comes in to see you for a problem, and you have to make that patient feel like they are the only person that matters at that time. I mean, I think that's really important. If I go to a doctor and I have a problem I want to be the focus of that problem; I want to know that the doctor has my back and that the doctor truly is there, invested in making me better. In the global market of medicine where everything's changing and companies are getting bigger, how do you provide that in a situation where it's always about needing to see more patients and spending less time with patients?"

"I think if you are going to be successful as a doctor you don't always have to be right, you don't always have to have a good result, but you always have to have the patient's back. And I think if every patient feels like they are your family and you treat them the same way as you treat your family, I think you'll be successful. Every physician would be successful. So, my advice to every medical student is just remember that every patient you treat, you should treat them like you would treat your family; make every decision like you would make it for your family, and I think if you do that, most of us will always do the right thing. We won't always have good results, but we'll be good doctors."

OSTEOPOROSIS

M. RUDWAN SOUKIEH



Osteoporosis is a public health disease that affects millions of people globally. It is a condition in which excessive bone loss causes a decreased bone mineral density (BMD) in affected patients. Meta-analyses have identified trends within certain populations that are affected more than others. Traditionally, increasing **age** and post-menopausal **hormonal levels** are common risk factors for osteoporosis and fractures (Aspray and Hill). A study from 2015 noticed a similar trend in Brazil, with the prevalence of osteoporosis in postmenopausal women somewhere between 15-33% (Baccaro et al.). This global phenomenon is further supported by a systematic review from 2016 in which osteoporosis was found to have a higher prevalence in females than in males, as well as in rural and southern areas as compared to urban environments (Chen et al.).

In an otherwise normal individual, bone is constantly being remodeled through the use of bone building and bone breaking cells, osteoblasts and osteoclasts, respectively. In osteoporosis, the reabsorption process is occurring at a greater degree than it can regenerate (Drake et al.). Because postmenopausal women are the most affected population and hypogonadism is a major etiology of osteoporosis in men, it is suggested that **hormone imbalances** play a role in the bone remodeling process (Bandeira et al.). Interestingly, even though the major etiology of osteoporosis in men is hormone related, hormone replacement therapy is not the standard treatment in these patients. Other forms of management aim to improve bone density or delay progression of bone loss with **supplementation** and **lifestyle changes**.

Osteoporosis management may include additions like vitamin D supplementation, increased calcium intake, and pharmacological therapy. However, it is equally important, if not more, to consider preventative measures. In a study by Dennison et al., the authors used data from the Global Longitudinal Study of Osteoporosis in Women (GLOW) to demonstrate that hypertension, heart disease, asthma, COPD, inflammatory bowel disease, Parkinson's disease, arthritis, multiple sclerosis, and diabetes are associated with increased risk of fractures (Dennison et al.). Of those listed, there are preventative measures for hypertension, heart disease, and diabetes. Another study identified progressive loss of balance, flexibility, postural stability, and endurance as risk factors for falling. The results from Wolf et al., suggest that an exercise routine that targets these areas of weaknesses, like Tai Chi, can **reduce the fear of falling** in an experimental cohort in which the mean age was 76 (Wolf et al.). Some patients might opt to, or can only handle, non-weight-bearing exercises such as swimming and walking, which can improve muscle strength, cardiovascular fitness, and coordination. However, with regards to bone density, it seems that bone loading, mechanical loading, and muscle contraction **promote bone formation** (Sinaki et al.). One study delved deeper into identifying that vigorous aerobic exercise, weight training, running, and playing squash improved bone mineral density in the hips, the lumbar spine, the radial bone, and bones in the racket hand (Todd and Robinson).

Interestingly, from a more psychological perspective, the fear of falling has been shown to be associated with a decreased health-related quality of life (HRQoL), as well as depression from not being as active as one used to be (Guillemin et al.). Comorbidities were found to affect individuals differently from one another, sometimes giving inconclusive, or contradictory, evidence for whether one comorbidity was associated with increasing or decreasing HRQoL. The only comorbidity that the authors found to be individually associated with a reduction in health utility was **depression**. This information brings into question whether certain patients might benefit from the use of emotional counseling to navigate through their emotions and grow the self-confidence they need to stay active and delay osteoporotic progression.

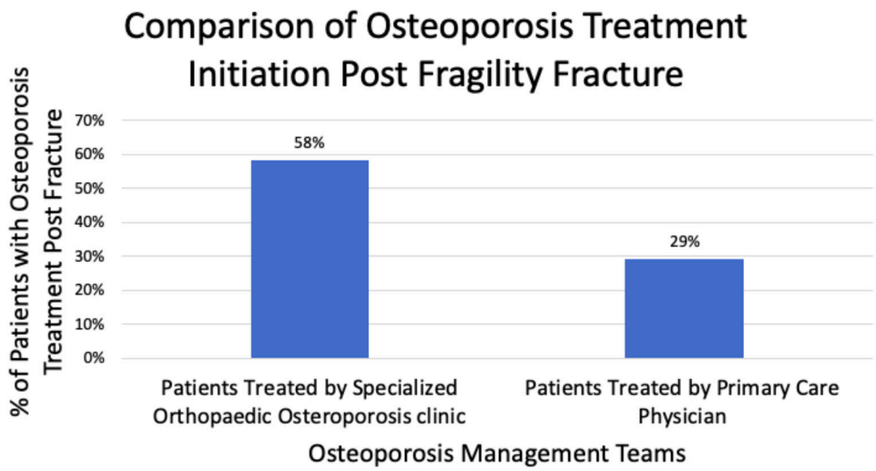
Finally, after learning more about osteoporosis, I realize there is still more that we do not know. There are traditional views of vulnerable populations, certain risk factors, and treatment options. With emerging research, more insight is given to understand different mechanisms of osteoporosis. Not only does decreased bone density affect the **body**, but it also affects the **mind**. There seems to be a growing demand for future management of osteoporosis to address different aspects of a patient's health and lifestyle choices while also counseling them to navigate through the negative emotions they may feel about their lifelong condition.

THE FUTURE OF OSTEOPOROSIS TREATMENT POST FRAGILITY FRACTURES

AMULYA R. SURAKANTI & MARC M. KESSELMAN

Osteoporosis is one of the leading causes of fractures in the elderly population >50 years old, especially women. As of 2004, approximately 10 million Americans over the age of 50 have been diagnosed with osteoporosis. Additionally, the annual cost of osteoporosis is also set to increase to upwards of $25 billion. Fragility fractures most commonly occur in the **hips**, the **spine**, **humerus**, and the **forearm**. Of these, hip fractures are often associated with the highest levels of mortality. The cumulative mortality that is associated with one-year post hip fracture is between 20-40% and there is an increased risk of refracture in the same location or getting additional new fractures.

Osteoporosis is often diagnosed using a dual energy X-ray absorptiometry (DEXA) scan, which measures the bone mineral density (BMD). While DEXA scans are the gold standard, they are oftentimes underused. According to a 2015 study, a 7- year cumulative incidence of 58.8% among 60–64-year-old women, 57.8% among 65–74-year-old women, and 42.7% among > 75-year-old women. There is also undertreatment of osteoporosis post-fracture. Of the patients who present with fragility fractures, only 9-20% of the patients are treated for osteoporosis. Undertreatment of osteoporosis post-fragility fractures also increases chance of re-fracture in untreated patients, which decreases the quality of life for patients and increases the risk of mortality. This underdiagnosis and undertreatment of osteoporosis calls for a more comprehensive and specialized care for patients with increased risk of osteoporosis and fragility fractures.



Fracture Liaison Service (FLS) is a multidisciplinary team approach that aims to prevent re-fractures and treat osteoporosis post hip fractures. In addition, Orthogeriatric Service (OGS) model is also a multidisciplinary team approach that provides care for elderly patients with fractures that are admitted to the hospital. FLS is shown to increase the rates of DEXA evaluations, improved prescription initiation rates for osteoporosis medications, and reduction in re-fracture rates. When comparing the effectiveness of FLS at tertiary hospitals, the hospital with FLS demonstrated approximately 30% reduction in any refractures and 40% reduction in new major fractures over a three-year period. In addition, FLS has been shown to be cost-effective as it both prevented subsequent fractures and increased quality-adjusted life years (QALYs). On the other hand, OGS has also shown to increase odds of diagnosing osteoporosis, and initiate treatment for osteoporosis. OGS has shown to decrease length of stay at the hospital, lower risk of in-hospital mortality, and lower risk of delirium. In addition, patients receiving OGS had improved mobility at 12 months post fracture when compared to usual orthopedic care. Implementation of FLS and OGS also shows **decrease in mortality within 30 days** and within one year in patients with hip fracture.

The introduction of FLS and OGS models changed the field of post fracture osteoporosis management. Initiation of pharmacological and nonpharmacological treatments post fracture has the potential to improve bone health, decrease re-fracture rates, decrease mortality and morbidity, and **improve quality of life**. The costs of follow up medical care and treatment have been shown to be reduced with the implementation of these services These models have been very effective at providing the care and attention that the elderly population with fragility fractures need. As the elderly population increases, the need for specialized care for the elderly becomes important to improve their quality of life and to receive cost-effective, comprehensive healthcare.

SURGERY IN THE METAVERSE: INTEGRATING VIRTUAL REALITY AND SURGICAL TRAINING

JONATHAN GROOTHOFF

Virtual reality (VR) is becoming increasingly popular in medical education and surgical training, as institutions seek to develop innovative ways to improve the delivery of care. Through a **head-mounted visual display**, VR technology immerses users in a safe, dynamic, first-person virtual world that can be programmed to mimic real-life medical scenarios. Instructors can watch the user's progress on an external monitor as tasks are completed, facilitating immediate and precise feedback critical to maximizing learning outcomes. Medical literature also indicates that virtual reality enhances student-driven learning. The ability to customize and easily repeat VR scenarios means that users can **tailor VR experiences** to target a particular area of personal growth, such as clinical reasoning, decision-making, or technical skills.1

Bryce Polascik (left), a third-year medical student at Wake Forest University School of Medicine (WFUSOM), was inspired by his first encounter with virtual reality while an undergraduate student at Duke University. After matriculating at WFUSOM, his curiosity regarding the potential intersections of medicine and technology led him to spearhead the formation of **"Surgery in the Metaverse"** (SIM). Guided by faculty mentor David C. Pollock, MD*, SIM provides hands-on, risk-free surgical training in virtual reality.

I recently had the opportunity to sit down with Bryce and ask him about SIM's innovative work in medical education, the state of VR utilization in surgical training, and areas of opportunity in the field.**

JG: Tell me a bit more about the current state of ***VR*** at Wake Forest University School of Medicine, and how have you seen both students and physicians utilize the technology?

BP: SIM is the first organization to provide dedicated VR medical training at WFUSOM. We have ***six VR headsets*** loaded with ***100 surgical procedures***. Students and physicians who have utilized our technology have found it to be a valuable tool for enhancing their medical and surgical education and training. In the medical literature, VR training has shown the potential to improve surgical ***proficiency***, increase ***confidence***, and ***reduce anxiety*** when performing procedures. Additionally, VR can increase access to hands-on experience, improve spatial awareness, and enhance early understanding of complex procedures. We have been very fortunate to receive positive feedback from our SIM events. At our most recent workshop, numerous first-year students had the opportunity to practice a variety of procedures, ranging from ***tibial nail placements*** to repairs of ***slipped cap femoral epiphyses***.

JG: What advice would you give to people at other institutions who may be considering ways to incorporate VR into medical education, but are wondering where to start?

BP: My advice is to start small and focus on a specific area of medical education or training. Identify a specific problem or challenge that VR can help address, and work to develop a solution that is ***tailored*** to your institution's needs and resources. It's also important to seek out partnerships with industry leaders, healthcare systems, and other organizations that can help support and advance the use of VR in medical education. VR can be a powerful tool for medical training, and early exploration of this field is vital to remaining at the cutting-edge of medical innovation and development.

JG: Where do you see opportunities for growth in the quality of medical VR simulations and the use of VR in medical education?

BP: Regarding the quality of medical VR simulations, as the technology continues to improve, we hope to see even more advanced simulations that can even better replicate real-world scenarios. We already have the capability to program in complexities to cases that force the user to adapt and problem-solve in real time, which adds a layer of realism to the experience. In terms of the use of VR in medical education, we believe that there is a huge potential for VR to ***expand*** into a variety of ***non-operative medical specialties*** and settings, such as telemedicine, preoperative planning, and patient education.

JG: What have you noticed are some of the challenges associated with employing VR technology in undergraduate and graduate medical education?

BP: One of the biggest ***challenges*** is the cost of equipment and software. Thus, for stakeholders, understanding the value of the investment is crucial. Additionally, there is a ***learning curve*** that can be a potential barrier to entry for some entry-level learners. SIM aims to address these challenges by providing early access to VR technology and offering hands-on guidance and support to new learners.

JG: What do you anticipate the intersection of VR and medicine will look like in the coming years, and what are potential future directions of VR in medical education and residency training?

BP: I anticipate that virtual reality in medicine will continue to rapidly grow and evolve, and I believe it will be widely adopted in medical education within the next five years. In ten years, I anticipate that VR will be an essential tool for surgical residency training, and that it will be used to provide more personalized and effective patient care. Future directions for this field include the use of AI and machine learning algorithms to improve VR simulations, the development of haptic feedback systems to enhance realism, and the integration of VR with other technologies such as robotics and augmented reality to optimize training and improve patient outcomes.

JG: Thank you for speaking with me. As we close, do you have any additional thoughts?

BP: I am incredibly excited for the potential of virtual reality to transform medical education and surgical training. I believe initiatives like SIM will play an important role in advancing the use of VR in healthcare, and it is an honor to be part of this movement. As we continue to innovate and explore the possibilities of VR in healthcare, I believe we will see improved outcomes, increased procedural efficiency, and a more effective approach to patient care.

* David C. Pollock, MD; Professor of Orthopaedic Surgery; Head of Adult Reconstruction at Atrium Health Wake Forest Baptist.

**This interview has been edited for brevity.

Interested in writing about a topic in musculoskeletal medicine?
We are now accepting submissions for the winter issue. Writing pieces can be submitted on the website, any questions can be directed to mskmatters1@gmail.com.
We are also accepting student artwork to be used for the newsletter! Submissions can be sent to mskmatters1@gmail.com

DIETARY PROTEIN IS THE MOST IMPORTANT MACRONUTRIENT. ARE YOU EATING ENOUGH OF IT?

FEGO GALVAN, PhD, RD

The importance of dietary protein is clearly outlined in the literature. Dietary protein is the most important macronutrient. There are many factors that contribute to this conclusion. A primary reason points to our inability to store dietary protein the same way we store carbohydrates (i.e., glycogen) and fat (i.e., adipose tissue). This is not to say that carbohydrates and fats are not important; they're just not as important with regards to skeletal muscle health. An equally important factor contributing to its importance is because of the intimate relationship between dietary protein and skeletal muscle metabolism. On average, we turn over approximately 1.2% of skeletal muscle protein per day and this turnover rate is in equilibrium between muscle protein synthesis and muscle protein breakdown. The relationship between muscle protein synthesis and muscle protein catabolism is an important concept to understand as increases in skeletal muscle mass only occur when muscle protein synthesis exceeds the rates of muscle protein catabolism. We generally understand the importance of skeletal muscle mass in terms of sports performance. Having more muscle mass and in turn, greater muscular strength and power, allows an athlete to run faster, jump higher, or move an opponent's body weight with greater ease (as is the case with combat sports like Judo, Wrestling, or Mixed Martial Arts). However, skeletal muscle mass plays a crucial role in overall health.

Skeletal muscle mass plays a vital role in whole-body protein metabolism by serving as a pool for amino acids required for protein metabolism of vital organs in the absence of protein intake (e.g., starvation, disease, trauma, etc). In the stressed state (e.g., illness, trauma, hospitalization) dietary protein requirements are increased and if the 'machine' is not being fed enough dietary protein, the body will acquire amino acids at the expense of skeletal muscle (i.e., muscle catabolism increases). Skeletal muscle mass has a protective effect against burn injuries and recovery from hospitalization[1]. It was found that survival from burn injury was lowest among those with lower skeletal muscle mass. Additionally, extensive loss of muscle mass and strength are significant contributors to physical impairments and prolonged recovery. Studies suggest that a preexisting deficiency in muscle mass prior to hospitalization or a traumatic event can push an individual over a threshold where recovery is unlikely to occur. This may help explain why half of formerly independent older adults never live independently again after a hip fracture[2].

Sarcopenia is the involuntary, age-related loss of muscle mass and strength. As we get older, we lose ~1% of our muscle mass each year from the age of 25 to 60 years old. Thereafter, muscle mass loss can reach ~5% annually. This should all be considered with the assumption that an individual is not actively attempting to prevent the onset of sarcopenia with behavior modifications via diet and exercise. With that said, it is safe to assume that the majority of the US population does not consume adequate dietary protein nor regularly participate in appropriate exercise (i.e., resistance training/weight lifting). A typical Western diet provides ~1.2 g protein per kg body weight. Later we'll see why this is a suboptimal amount of dietary protein to maintain muscle mass. Epidemiological data reports that 75% of US adults are overweight (BMI: 25-29.9) and obesity (BMI >30), while ~40% are obese[3]. The obesity rate is expected to be ~50% of the US population by 2030[4]. This data suggests that the majority of the US population does not regularly perform exercise activity. So now we have set the stage for some of the factors (i.e., lack of adequate dietary protein and exercise activity) that contribute to sarcopenia.

Sarcopenia is typically thought of as a condition that only affects older adults. However, I would argue that the foundation for developing sarcopenia and the chronic conditions that accompany the loss of muscle mass and strength are cultivated during our second decade of life. Kirk and Paddon-Jones illustrate the difference between the traditional Sarcopenia Model versus the Catabolic crisis model[5]. In the traditional Sarcopenia Model, we think of muscle loss as a gradual progression throughout adulthood. However, the Catabolic crisis model accounts for life events (e.g., illness, hospitalizations, injury) that lead to periods of disuse (i.e., bed rest), which increases the rate of muscle catabolism during bed rest and period of recovery which never quite make it back to baseline (i.e., prior to illness, hospitalization, or injury). Over time, this eventually results in a significantly lower muscle mass in the Catabolic Crisis Model compared to the traditional Sarcopenia Model. Figure 1 below illustrates that Sarcopenia typically does not gradually occur over our lifespan[5]. What typically happens are periods of inactivity at various stages in our lives that result in disuse. Consider what happens when we get sick or

are hospitalized due to an injury. We typically lay in bed during the initial stages of the illness/injury and during the recovery period. We know that bedrest leads to muscle loss and the rate of muscle is dependent on the gravity of our illness/injury. In other words, the catabolic crisis of multiple bone fractures due to a motor vehicle accident would be expected to be more detrimental to muscle loss than catabolic crisis of one bone fracture. Thus we would expect to lose more muscle mass during the more severe catabolic crisis (e.g., multiple fractured bones).

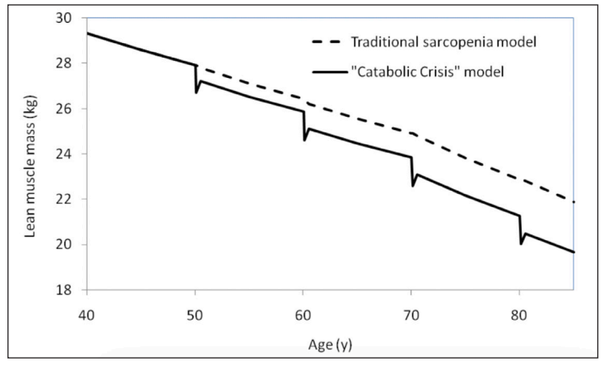


Figure 1.
Proposed model of age-related loss punctuated by episodes of acute illness or injury and characterized by accelerated muscle loss and incomplete recovery. English et al. [5]

Muscle Loss During Disuse

Several different disuse models have been used to quantify the rate of muscle loss. Some researchers use a cast model, where they immobilize one leg in a cast-like apparatus. Others use a bedrest model, where healthy, study participants of various ages are asked to lie in bed for days to months at a time. For the purpose of this article, we will mainly look at findings from bed rest studies. The amount of muscle loss experienced during disuse depends on several factors – health status, age, and duration of disuse. A recent meta-analysis analyzed the muscle loss associated with short (1-10 days) , medium (11 days to 1 month, and long-term (> 1 month) bedrest[6]. Prolonged disuse as seen during bedrest (even short term bed rest) results in skeletal muscle loss in leg musculature, specifically the quadriceps femoris. Data revealed a muscle mass loss of 1 to 4% (short-term), 6 to 11% (medium-term), and 9 to 21% (long-term) in healthy 18 to 50 year old test subject. We would likely expect even greater losses of muscle mass with chronic condition (e.g., diabetes) and/or injury (e.g., hip fracture). It is important to note that the majority of muscle atrophy typically occurs in the first few week of bed rest[6]. However, this can vary, and it is highly dependent on age. During a one-week long bedrest study, 60 to 80 year old participants lost approximately 1 kg (2.2 lbs) of skeletal muscle mass[7]. One kg of muscle may not seem like a lot, but consider that under optimal conditions (e.g., a research study with nutrition/exercise oversight). This is important as in 2018 there were 36.4 million inpatient hospital stays in the US, with the average length of stay for a hospitalization being 5.5 days. In a review

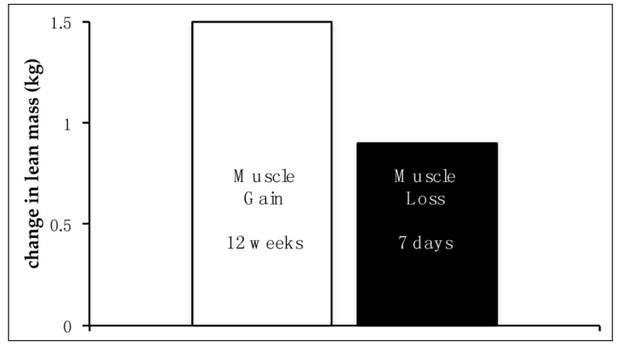


Figure 2.
Gains in muscle mass and function due to exercise require consistent training over an extended period of time. Twelve weeks of resistance training results in a modest gain (~1.5 kg) in muscle mass in older adults [9]. However, loss of muscle health due to disuse occurs over a very short period of time; seven days of bed rest is sufficient to induce ~1 kg loss of leg lean mass alone. Given the effort necessary to maintain muscle health, especially during aging, strategies that protect muscle during disuse are critical.

article, Galvan et al reported modest gains in muscle mass (~1.5 kg) in older adults with 12 weeks of resistance exercise training[8].

Optimal Protein Intake

Optimal protein intake is completely dependent on the demographic. In order to determine optimal protein intake, you have to consider several factors – age, exercise activity, heath status, protein source, and body composition goals. Athletes will require more protein than their sedentary counterparts and hospitalized patients will typically require more protein than their healthy counterparts. Muscle protein synthesis (MPS) is often an outcome measured to determine the efficacy of a nutrition, exercise, or pharmacological intervention. MPS is metabolic process that describes the rate of amino acid (e.g., dietary protein) incorporation into bound skeletal muscle proteins. In other words, if MPS is increased overtime, this increase in MPS can result in skeletal muscle hypertrophy, with a concomitant increase in muscular strength. MPS can be influenced by three factors – nutrition (i.e., dietary protein), exercise (i.e., weight lifting), and pharmacological agents (e.g., anabolic steroids).

Symons et al. compared fasted (post-absorptive) and after a meal (post-prandial) MPS in both young and older adults[10]. Researchers observed a 25% increase in post-prandial MPS in both young (~40 yrs old) and older (70 yrs old) following a 30 g serving of protein (4 oz of beef). In a follow up study, they found that there was no significant increase in MPS following a 90 g serving of protein (12 oz of beef) in both young (35 yr old) and older (68 yrs old) adults[11].

DIETARY PROTEIN IS THE MOST IMPORTANT MACRONUTRIENT.
ARE YOU EATING ENOUGH OF IT? CONTINUED...

FEGO GALVAN, PhD, RD

In a different study, the researchers were interested in how the addition of exercise would influence rates of MPS [12]. Young (30 yrs old) and older (70 yrs old) adults performed 6 sets of 8 repetitions of leg extension exercise at 80% of their one-repetition maximum, 1 hr after consuming 90 gram of protein. Post-absorptive MPS was similar in both groups. MPS in both groups was increased ~100% following exercise + 90 g protein compared to post-absorptive state. This is great news. It was typically thought that older adults had a blunted response to dietary protein as muscular function tends to insidiously deteriorate as we age. However, research observed a significant difference in MPS when older adults (i.e., anabolic resistance) did not meet the dietary threshold of dietary protein (20 to 30 g protein) at any given meal. Young (30 yrs old) and older adults (68 yrs old) were given 15 g of protein and net muscle protein synthesis was measured 3.5 hrs following the ingestion of the protein [13]. There were no differences in between young and old at baseline; however, the mean response in the older group was ~40% that of the response in the young adults.

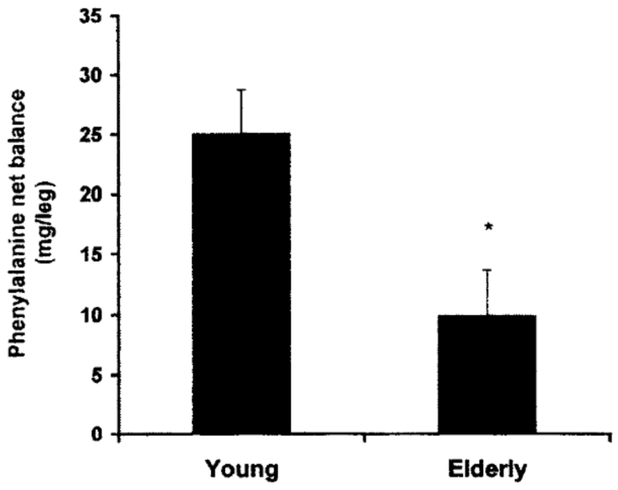


Figure 3.
Mean (±SEM) leg phenylalanine net balance 3.5 h after the ingestion of essential amino acids calculated by measuring the area under the phenylalanine net balance response curve in the elderly and the young. Data were analyzed with a t test. *Significantly different from the young, P=0.010 [13].

This is important to considering the typical Western diet – very little protein at breakfast (5-10 g protein), a little more protein at lunch (10 to 15 g), then larger servings at dinner (>60 g protein) [14]. In other words, the amount of protein is skewed throughout the day instead of being evenly distributed. Instead of simply throwing more protein at the problem, a more practical solution would be to take protein away from dinner and evenly distribute it throughout the day. Researchers aimed to observe 24h MPS of skewed (10 g at breakfast, 15 g at lunch, and 65 g at dinner) vs evenly distributed (30 g at each meal) in healthy adults (25 to 55 yrs old) [15]. There was a 25% increase in 24 h MPS with the evenly distributed protein group compared with the skewed protein group. It is important to consider the amount of protein at each meal and not only total daily protein. In the study above, both groups received a total of 90 grams of protein per day; however, the skewed protein group clearly missed out on optimizing MPS at breakfast and lunch.

It is clear that adequate dietary protein intake is substantially more important to skeletal muscle health as we get older. If you're still not convinced, let's look at the loss of lean leg mass in various age groups. Kortebein et al observed a 0.95 kg loss in leg lean mass in older adults (67 yrs old) following 10 days of bed rest [16]. Researchers observed a 1.2 kg loss in leg lean mass in older adults (52 yrs old) after 14 days of bed rest [17]. Paddon-Jones et al observed a 0.4 kg loss in leg lean mass in young adults (~35 yrs old) after 28 days of bed rest [18]. Another way to look at dietary protein intake is to consider the amount of protein per kg body weight. Many people inaccurately cite the US Recommended Dietary Allowance (RDA) of 0.8 g/kg/day as the optimal or sufficient amount of protein an individual needs [19]. The RDA is defined as "The recommended dietary allowance (RDA) is an estimated of the minimum daily average dietary intake level that meets the nutrient requirements of nearly all (97 to 98%) healthy individuals." NHANES data for 2017 – 2018 reports ~30% of adults are overweight (BMI 25 to 29.9), 42% are obese (BMI >30), and 9% have severe obesity (BMI >40) [20]. I would argue that the RDA would be inappropriate for these populations as being overweight/obese excludes them from being "healthy". We also have to consider the increasing aging population in the US. In the US, there are currently more than 50 million adults older than 65 yrs and this population is expected to exceed 80 million by 2040. Therefore, citing the RDA as the optimal amount for most individuals is vastly inadequate and inappropriate.

Yet major organizations continue to misuse the RDA. For example, the British Heart Foundation states "most adults need around 0.75g of protein per kilo of body weight per day (for the average woman, this is 45 g, or 55g for men)." Generally, most sports nutrition scientists agree on generalized protein recommendation based on activity level (sedentary vs active) and exercise activity (endurance vs resistance training). Generally, sedentary individuals require less daily protein than their active counterparts. It is recommended they consume 1.2 to 1.5 g/kg/day [21]. Endurance athletes (e.g., swimming, running, cross-country skiing) require slightly less than resistance training athletes. Endurance athletes could benefit from a protein intake of 1.5 to 2 g/kg/day [22]. Resistance trained (e.g., body builders, power lifter, wrestlers) may benefit from >2 g/kg/day [23, 24]. for sedentary. Greater than 3 g/kg may be optimal for severe catabolic condition (e.g., wound, HIV, cancer, burn injury) [1].

It should be clear that dietary protein plays an important role in overall health as we all age. It can play a significant role in how we age and the quality of our lives over our lifespan. Muscle mass generally peaks in our late 20s, and subsequently declines with age, unless measures are taken to mitigate the age-related negative effects on muscle mass. This insidious decline in muscle mass often goes unnoticed and is unproblematic for decades. Thus, it often goes unnoticed until it's too late. We know that a decrease in muscle mass in older adults can have a significant negative impact on mobility, quality of life, and mortality. So, the question is, when was the last time you made sure you consumed 30 to 40 g of high quality animal protein at each meal in addition to weight training (I'm looking at you, ladies)? It's usually never too late (i.e., assuming the absence of chronic diseases) to start modifying your dietary and exercise habits. But at a certain point a person's health is too far gone and introducing exercise like weight training becomes too dangerous to one's health. For example, in a study on young, healthy, experienced body builders performed different weight lifting exercises [25]. The greatest peak in blood pressure occurred during the double-leg press exercise. The mean value for the group was 320/250 mm Hg, with blood pressure measurements in one subject reaching 480/350 mm Hg! For this reason, heavy weight training is not recommended for individuals with Chronic Heart Failure. Let's make those dietary and exercise changes early and often before it's too late.

TAI CHI AS A CONSIDERATION IN CHRONIC MUSCULOSKELETAL PAIN

JUSTIN PHILLIPS, L.Ac

In the treatment of pain there is a critical need to constantly consider novel treatments outside the direct interventions of pharmaceutical and surgical approaches, especially those that can be adopted as lifestyle practices. With **one in five Americans** suffering from some form of chronic pain, the ability of clinicians to render care is limited.[1] By understanding lifestyle practices that can offer some pain relief and even long-term health changes, the clinician can empower their patients to take active steps in the maintenance of their own pain conditions.

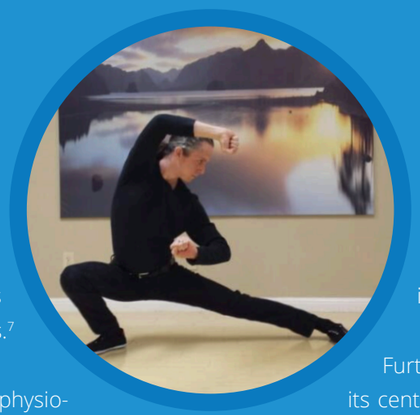
Tai Chi is growing in popularity among Americans, especially in older populations.[2] It has been shown to have positive effects on musculoskeletal pain in several studies. Additionally, it has been shown to be more effective than aerobic exercise in the management of fibromyalgia and has demonstrated efficacy in the treatment of knee osteoarthritis.[3,4]

For a clinician, it is not only important to understand which therapies might show benefit to a patient but also to **understand the mechanisms** behind that efficacy so that therapies can be assigned to the patients that would most benefit from them. While the exact mechanisms of Tai Chi's effect on chronic musculoskeletal pain are layered, there are several physiological effects that have been elucidated.[2]

In terms of chronic pain, one of the most significant areas of improvement with regular Tai Chi practice is muscular **strength** and **range of motion**.[5] This is consistent with other movement programs such as load bearing exercise and aerobics. Tai Chi, however, is typically practiced with very slow movement and no additional weight, which can make it highly suitable for elderly or otherwise compromised patients. The emphasis on slow, controlled movement can also lead to a decrease in the incidence of exercise-related injuries, especially if practiced under the supervision of a qualified instructor.[6]

In addition to both the decreased strain and reduced possibility of injury, the slow and progressive quality of Tai Chi training can also allow patients to explore a broader range of motion, which can be beneficial in the management of both the primary and secondary symptoms of knee osteoarthritis as it will both restore lost range of motion but can also facilitate an increase in bone density.[4,5]

Tai Chi can also decrease the incidence of falls in senior populations, which suggests that the practice of Tai Chi can not only decrease the prevalence of chronic pain, but also reduce the risk of future fall traumas, which can reaggravate existing pain conditions or create new ones.[7]



Outside of the purely physiological benefits of Tai Chi, there is also room to consider the ecopsychosocial impact of Tai Chi practice as well as the neurophysiological. It is known that social factors, such as interpersonal interaction and life satisfaction, can have an impact on pain perception, especially in cases of chronic pain.[8] Tai Chi is typically practiced in-person in a **group setting**, which can help patients develop a stronger social support network around their recovery process.

In addition, it is possible to consider the neuroplastic nature of chronic pain and the patient's relationship with that pain. A patient's awareness and perception of their pain can have a significant impact on their self-reported pain scales and quality of life measurements.[9] Tai Chi is generally considered to be not only a physical fitness practice but also a mindful and **mind-body practice**. This can have two obvious benefits in relation to recovery from chronic musculoskeletal pain. The first and more obvious is the mind-body connection in managing the neuroplastic aspects of long-term pain. A patient who can bring attention to an area of pain in a positive way will often see improvements in that pain even when there is no measurable change in physiological structure.[9]

Furthermore, in considering the role of the brain and its centrally integrated state on pain perception, the level of plastic aptitude can be addressed. Although in more recent studies it has been demonstrated that the human brain retains a degree of neuroplasticity throughout life, it still decreases as patients age.[10] Tai Chi is demonstrated to be an excellent practice in maintaining plastic aptitude via novel proprioceptive learning.[11] This, combined with the slow, mindful nature of the practice, can dramatically aid patients in relearning healthy movement behaviors and decrease the level and impact of chronic pain.

While Tai Chi is highly suitable for elderly or impaired patients, it is also an excellent practice for young people. Many of the physiological pain issues faced by modern Americans can be related to life-long postural issues.[12,13] Children respond well to the neuroplastic training induced by physical activity and can be taught the valuable postural understanding inherent in Tai Chi practice early in life.[14] By including younger patients in these practices, clinicians can hopefully reduce the number of chronic pain cases in the upcoming generations.

THE USE OF SMARTPHONE TECHNOLOGY AND WEARABLE DEVICES IN PATIENT CARE

ANDREW BEAUPERTHUY

In a society that is trending towards digital technology use and an increase in telemedicine, there has been a recent interest in the use of wearable and smartphone technologies to monitor patients remotely. This has become especially useful to monitor patients following orthopedic surgery.

There have been smartphone applications as well as wearable knee sleeve sensors that have the ability to continuously measure mobility (via step count), range of motion, patient reported outcome measures, opioid use, and home exercise programs [1]. While much of this information has classically been obtained from progressive in person follow-up visits, doctors can now receive continuous information regarding the recovery of their patients. The most common wearable sensors that have been used for joints include accelerometers, to measure acceleration, gyroscopes, to measure angular velocity, and magnetometers, to sense body orientation [2]. The combination of these three measurements are referred to as inertial measurement units (IMUs) or inertial sensors. Inertial sensors can obtain values regarding three dimensional gait analysis, impact load on a joint, range of motion (i.e., flexion angles) [1,4]. An example of how these measurements, with the use of smartphone applications, can be used to monitor patients with osteoarthritis preoperatively.

Even before surgery, this data can be used to evaluate the progression of disease [3]. Additionally, they can be used post-operatively to remotely monitor the recovery process.

In a study with 25 participants undergoing total knee arthroplasty, patients downloaded a smart phone app that was paired to a wearable knee sleeve, and collected baseline data pre-operatively, as well as data post-operatively for three months [1]. Data was continuously obtained, and included information regarding range of motion, steps taken, and opioid use. On average, patients returned to pre-operative baseline by the six week mark and were 30% above baseline by three months [1]. This study shows that it is possible to remotely monitor patients following total knee arthroplasty using these smartphone technologies.

The combination of the smartphone applications and wearable devices has also demonstrated increased motivation for patients within their recovery process. These applications have the ability to deliver and monitor benchmarks for recovery [5]. Although much information can be inferred, further research must be done to understand how such wearable devices and smartphone applications can affect outcomes in the field of orthopedics such as post operative complications, recovery time, and cost of healthcare. With that said, there is a promising outlook on how the application of wearable devices can affect these factors.

ELECTRIC CITY CLASSIC

MAYA VAN GIESON

The Electric City Classic is a weekend of cycling races that occurs in downtown Scranton every August. This event attracts cyclists from all over the United States and all over the globe! It also showcases the incredible training these athletes undergo and the remarkable health benefits of cycling. Furthermore, this event often offers GCSOM students the opportunity to volunteer and put their patient care skills to the test!

The Electric City Classic has the famed "Hill Climb" race, where cyclists race against the clock and each other to make it up the hill in the Hill section of Scranton. The rest of the Electric City Classic is called a Criterium race or "Crit" for short. A Criterium race involves a short course with multiple turns that riders complete numerous laps around. The Electric City Classic has various categories based on skill level, type of bike, and level of competition. The impressive athletic nature of cyclists, creative races, and various vendors make this a great event for participants and spectators alike!

While this event offers cyclists and spectators a chance to exercise their social health, the sport of cycling has various health benefits. Various systematic reviews investigating the health benefits of cycling concluded that cycling is associated with increased cardiovascular fitness in both youth and adults. Specifically, many of these studies demonstrated a positive dose-response curve between the amount of cycling and experienced health benefits.1 Even if one is unable to perform conventional or "road-style" cycling due to health reasons, time constraints, or other reasons, they can still benefit from electronically assisted cycling (e-cycling) or indoor cycling on a stationary bike. E-cycling refers to a variety of bike designs that all involve some external source of power that the rider can use to propel the bike. These e-bikes are great for the middle-aged or older population that may need additional assistance while riding, those with a long commute, and various other situations. E-cycling offers similar health benefits as conventional cycling; however, one needs longer and/or more frequent rides to achieve similar effects.2 Indoor cycling, like conventional cycling, has positive cardiovascular benefits, specifically in improving aerobic capacity. Furthermore, indoor cycling combined with diet modifications can lower blood pressure noticeably over the course of six months. Therefore, cycling in its multiple forms has positive effects on physical health, most notably on cardiovascular fitness.

Jeffery Mun (Class of 2025) also says that while cycling keeps him physically fit, it also encourages him to "explore the nature trails and cities around the area... [and] find new restaurants". He also notes the benefit incorporating cycling into his life has had on his mental health. He explains, "I think the challenge of biking helps me build resilience" as well as how "it's also a form of meditation for me...focusing on the rhythm of my pedaling, my breathing, and being present with the outside surroundings". Jeffery recommends an 8-mile cycling route near Harvey's Lake in Dallas, PA, to anyone interested in cycling in the area. However, his "favorite route outside of PA is a gravel trail called the Washington and Old Dominion (W&OD) Railroad...in the Virginia/DC area".

If the literature, Jeffery's experience, or excitement of the Electric City Classic inspired you, consider volunteering at the 2023 Electric City Classic! As with all professional sporting events, there is a medical team on standby for any health-related adverse events that may occur. Often, doctors and residents from various specialties, including sports medicine, orthopedics, physical medicine, and rehabilitation (PM & R) from Geisinger comprise the core medical team. In recent years, they have also offered GCSOM medical students the opportunity to volunteer at the event under the physician's supervision. Some GCSOM students, including myself, got to volunteer at the 2022 Electric City Classic and we enjoyed our time volunteering. I (Class of 2025) personally recall an athlete who sought first aid after falling off his bike in the race. Under the physician's supervision, I was able to clean and dress his abrasions as well as converse with the cyclist. I learned he had traveled all the way from the Bahamas to participate in the race! Caring for this cyclist improved both my wound dressing and patient interaction skills. I found this to be a great opportunity for medical students like me to practice first aid skills and learn from experienced physicians.

Therefore, cycling has incredible health benefits, especially regarding cardiovascular fitness as well as mental health. Whether you're looking to improve your patient care skills or watch a few exciting cycling races, be sure to look out for the opportunity to volunteer for the Electric City Classic in August 2023!

CONSISTENCY OVER HYPE: HOW INFLUENCERS INADVERTENTLY UNDERMINE THE FOUNDATIONS OF MUSCULAR HYPERTROPHY

JEFFERSON WATERS

Historically, the fitness community has promoted the belief that training in high repetition "rep" ranges (16+) is ideal for muscular endurance training, mid-range (8-12) is ideal for muscular hypertrophy, and lower rep ranges (1-6) are more suited for strength training. This notion was termed "the Repetition Continuum".1 Recently, however, YouTube and TikTok fitness influencers have espousing the idea that training to failure in a lower rep range and even using fewer sets for each exercise is a more effective method of training. They argue that working at a lower volume generates less fatigue over time while maintaining a similar level of muscle unit activation. This theory continues to be controversial,2 but even under the assumption that it is valid, the emphasis on a single important factor can mask the importance of other critical components. It, like other niche recommendations, predisposes a novice to train less effectively despite the incorporation of potentially legitimate advice.

Studies have shown statistically different muscle growth between low and intermediate rep ranges,3 but such growth is not necessarily great enough to be visible. Several other factors, such as diet, effort (training to failure), and technique contribute more significantly to muscle growth.4 Ultimately, however, consistency in training is the most important factor contributing to muscular hypertrophy.5

When studying for a test, cramming at the last minute may make the difference of a few percentage points. The number of repetitions performed for an exercise has a similar influence on training. In this analogy, rep range and correct form change the grade a small amount, diet and increased effort do so to a greater extent, but consistency is what earns the passing grade. In summary, it is crucial to eat well, use effective rep ranges, and practice good technique **over time**. Consistency is both necessary and sufficient for progress, while other factors such as rep range only modulate the effect of consistency. The emphasis on rep range is akin to other fads that fitness personalities have endorsed. The influencer's jump to a certain exercise or training frequency similarly disguises the importance of the other fundamentals of training, namely consistency. So, when a young, impressionable teen sees a muscular influencer on TikTok promoting a certain training style as advantageous, they develop an expectation of rapid results without any additional context. Unfortunately, they do not see the diet, effort, and consistency that the influencer has practiced for many years to achieve their physique. At best, this can result in a delay in the development of an effective training regimen. At worst, the novice weightlifter may quit early due to an inability to achieve their unrealistic expectations.

Acceptance of slow growth in muscular hypertrophy training allows for consistency. Even the person who trains using the best exercises, diet, and rep ranges may not see a difference in a week, 2 weeks, or even a month. However, the person who continues to train for an extended period, whether under optimal conditions or not, will inevitably notice growth. Without recognizing this, modern fitness influencers can be destructive to athletes' progress. They do not necessarily provide false information, but they often fail to emphasize the proportional significance of each component of a successful training regimen.

MSK_MATTERS

A BRIEF LOOK AT ***RESEARCH YEARS***: PERSPECTIVES FROM TWO DIFFERENT EXPERIENCES

ADAM COLE

In competitive residency programs, it is becoming increasingly difficult to distinguish oneself from other candidates. With the transition of the USMLE Step 1 Exam to a pass/fail scoring system, emphasis must fall on other components of one's residency application. Likely, one area of importance will be the applicant's research-related experiences, whether that be in the form of abstracts, posters, presentations, or full publications.

I imagine most medical students would likely agree that free time is not in abundance, particularly during the didactic portion of schooling. Yet, despite the time constraints, finding time to conduct research, write articles, and present academic work at conferences is expected (dare I say, necessary) for most competitive specialties. As a result, one might find that to build a strong application, dedicated time to conduct research might be required.

One solution to this dilemma is to take a so-called Research Year. While there are many variations and types, each works in a similar way. In short, a student applies for a year-long position to conduct, wait for it, research. This often takes the form of a paid position at a teaching hospital and/or medical school, essentially working a full-time job for the year. Unfortunately, it requires a one-year hiatus from school, inevitably delaying one's graduation by a year.

Wanting to hear firsthand accounts about research years, I recently interviewed two individuals who separately participated in this endeavor: Brandon Smith, a soon-to-be DO graduating from Liberty University College of Osteopathic Medicine and recently matched orthopedic surgery resident, and Alex Tang, MD, a first-year orthopedic surgery resident at the Geisinger Northeast Residency Program.

"What were your primary motivations for doing a research year?"
Alex had the unique opportunity to participate in two separate years of research, once between his third and fourth years of medical school and then an additional research year after unsuccessfully matching into an orthopedic surgery residency. Alex opted to do his first research year not only to add publications to his resume but also to network and work within the field of orthopedics and determine if it was the right fit for him. He saw it as a refining tool he could use to narrow down which specialties he liked best. In contrast, Brandon knew he wanted to pursue orthopedics. He viewed his research year as a way to increase his knowledge of musculoskeletal anatomy, with the hope that he would be better equipped for his clinical rotations, particularly his third-year rotations and ultimately his audition rotations in his fourth year. In either case, Alex and Brandon wanted to do more than just conduct research and simply strengthen their "on paper" application; they wanted to improve the intangibles of 1) networking and gaining mentors and 2) improving their musculoskeletal knowledge base with the hope of becoming more comfortable during clinical rotations.

"What were the benefits of participating in your respective programs, considering both immediate and long-term benefits?"
After interviewing both individuals, it was clear that no two programs are designed the same. Brandon explained that his program focused on hands-on anatomical learning rather than solely on research. Alex, however, discussed how his work was a combination of both clinical medicine and research. Alex explained how he consistently interacted with residents & attendings, and this was the biggest benefit he described for the year. Specifically, he believed that his interactions significantly improved his chances of matching into a residency program through networking, gaining mentors, and building strong connections with those who could advocate for his residency placement.
For Brandon, the biggest benefit was gaining an invaluable understanding of musculoskeletal anatomy. He believes this improved his chances of matching into orthopedics because he was comfortable answering anatomy questions in the operating room, as well as gaining what he described as "practiced hands" from doing cadaver dissections as part of the program. Overall, both Brandon and Alex believe their respective programs positively helped their applications.

"Did you have expectations heading into the year, and if so, were they met?"
Alex and Brandon both admitted to having preconceived ideas and expectations for their programs. Brandon felt it was very different from what he expected due to the then-new COVID-19 pandemic, which changed how the year was structured, with transient rules and regulations established in response. Many of the clinical and physician interactions were unavailable to him as well. For Alex, while his original expectation of publishing papers was met, he quickly realized there was much more to his program. Alex pivoted early on from publishing as many articles as he could to establishing relationships, networks, and mentors. Building rapport with attendings required intentional work and effort, and in the end, he believes this ultimately helped him more than any number of publications could.

"Would you do it again? And what would you say to those who are considering participating in a research year?"
I received strikingly similar responses from the two. In short, yes, they both admitted they would do their research years again (and in Alex's case, he did get to do it again, just at a different program). On the question of who should consider a research year, both individuals emphasized that it must be a person-by-person decision. There are no broad brushes to paint with, mainly due to the countless variables that come into play: test scores, current research portfolio, class rank, personal situations, and interest level in conducting research, just to name a few. On the flip side, Alex and Brandon both explained that they believe the biggest deterrent to doing a research year is the unavoidable reality of adding an additional year. As a result, one must weigh their own goals and plans and make the decision that is most appropriate for the individual.

Ultimately, participating in a research year can be an incredibly rewarding experience. Alex and Brandon are just two of thousands of individuals who have participated in such programs. With that in mind, research is not the only factor that strengthens an application, nor is it the sole determinant of a candidate's competitiveness. As Alex stated, "Research is great, but [it] can only help so much. It is really your entire package that will make you a strong candidate for residency." Strong residency candidates are more than just accomplishments listed on a paper. Research is just another tool in the toolbelt to help in the journey of matching.

EFFICACY AND LIMITATIONS OF 3D PRINTED IMPLANTS IN ORTHOPEDIC SURGERY: AN INTRODUCTORY REVIEW

KELLY LONG

Recent advancements in technology are constantly being utilized in medicine to achieve the best possible outcomes for patients while minimizing adverse effects and complications, and the field of orthopedic surgery is no exception. One of the newer tools proving to be beneficial for orthopedics is 3D printing. 3D printing has revolutionized the field of orthopedic surgery by enabling the creation of custom implants tailored to individual patients' unique anatomy. The process involves a variety of techniques and uses a range of materials to produce these implants, including metals, ceramics, and polymers. The choice of material depends on the specific application and requirements of the implant as materials such as titanium and cobalt-chromium alloys are commonly used for load-bearing implants, while polymers such as polyetheretherketone (PEEK) are preferred for implants required to be flexible and lightweight.[1]

The printed implants have several applications in orthopedics including serving as models for training, guides during procedures, and patient specific instruments such as screws and scaffolding.[2] For joint replacements, 3D printed implants can provide better fit and reduce the risk of complications like implant loosening. In spinal surgeries, 3D printed implants can be tailored to fit the complex anatomy of the spine which helps retain its normal curvature. And in traumatic injuries, these implants can be used to repair and reconstruct large bone defects.[1]

The use of 3D printed implants offers several advantages over traditional implants, such as increased customization and dimension matching, which leads to superior reduction of tibial plateau fractures with reduced risk of implant failure and greater post operative mobility.[3] When employed in anterior cervical discectomies and fusions, 3D printed cages retained cervical spine lordosis, encouraged bone growth, and shortened surgical time by removing the need for bone grafting.[4] Additionally, cases of talus arthroplasty for avascular necrosis and navicular fracture repair with 3D implants showed enhanced implant incorporation with superior fixation stability.[5]

Despite the apparent benefits, there are also some limitations to the use of 3D printed implants in orthopedic surgery. One of the major limitations is the cost of 3D printing, which remains high.1-6 Because of this, many insurance providers may not cover the cost of 3D printed implants, making them less accessible to patients. Likewise, technology required for 3D printing is not widely available within medical facilities which may additionally limit accessibility.[1]

The time required to produce some implants proves to be another limitation. 3D printing can take several hours to produce a single implant[1,5-6], which may delay the surgical process. The ability to properly sterilize the implants can also be challenging due in part to some materials having poor tolerance to high temperatures or deep microbe adherence to textures used for improving bone growth and fixation.[2]

In some cases, such as cervical discectomies and fusions, the coating of 3D implants may increase rates of intervertebral fusion or spinal instability.[4] There is also a lack of long-term data on the efficacy of 3D printed implants. While studies have shown promising results in the short-term[2-4], there is limited information on how these implants will perform over time and further studies are necessary to determine the durability and longevity of 3D printed implants.

3D printing technology has largely shown promising results in the field of orthopedic surgery. These implants offer increased customization, enhanced fit, and reduced surgical time which can all lead to lower rates of complications and implant failures.[3-5] However, cost and accessibility, design and production time, and lack of long-term data on efficacy are significant limitations that require further improvement or investigation. As technology continues to advance these limitations will likely be addressed, making 3D printed implants a source of significant potential in the continued quest for optimal patient care.

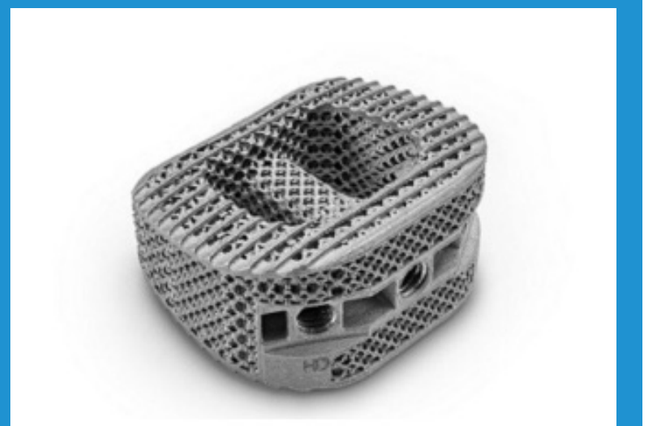


Photo Credit: NanoHive Medical

ADIPOSE TISSUE AND ITS POTENTIAL ROLES IN SKELETAL MUSCLE REPAIR

MARY TRAN

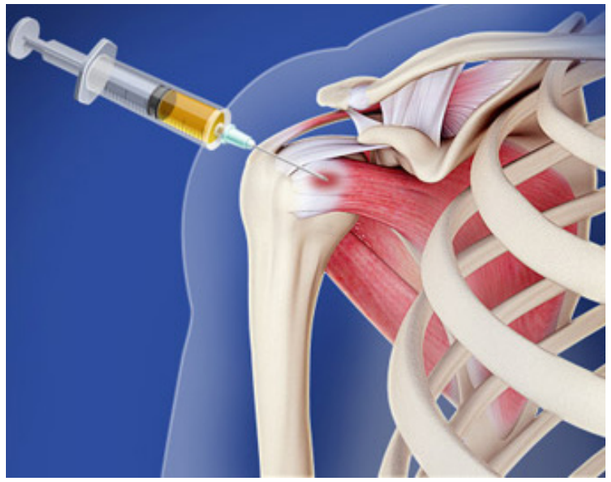
Skeletal muscle has a high capacity for regeneration after injurious diseases such as muscular dystrophy or severe trauma. The process of skeletal muscle has traditionally been explained in terms of **satellite cells** and **myogenic progenitor cells** (1). The capacity for skeletal muscle regeneration is oftentimes compromised in certain cases which leads to chronic muscle weakness and wasting. However, **fibro-adipogenic progenitor (FAP) cells** have shown the potential in playing a role in skeletal muscle regeneration.

FAP cells are resident stromal cells located within the interstitial space of the myofibers (2). Other resident cells responsible for processes such as inflammation include macrophages and satellite cells. All of these cells play a role in skeletal muscle repair response following damage. FAP cells have been known to play a special part in orchestrating this process (2). This has resulted in clinical trials that have shown promising results of directly using adipose stem cells as a therapy for muscle repair.

One study tested this by directly transplanting human **adipose stem cells (ASC)** into an area of skeletal muscle following injury. Using rabbit models, ASC was injected into one side of the buttocks area that was injured via radiotherapy. A control group was conducted using phosphate-buffered saline instead. Compared to the control group, several findings were observed 26 weeks post-transplantation. Expression of vascular endothelial growth factor (VEGF) and basic fibroblast growth factor (bFGF) was **upregulated** in the group that received ASC transplantation (3). Additionally, **compensatory hyperplasia** was observed in the ASC group along with neomyofilament structures (3).

Another study explored this further, finding that ASCs were released from subcutaneous adipose tissue in response to muscle injury and home to the area of damage (4). In mice, it was found that the number of FAPs spiked within the next 24 hours of induced muscle trauma peaking at 96 hours (4). The trafficking of ASCs was correlated with platelet cells. It was shown that blocking the homing of ASCs impaired the process of muscle regeneration (4).

The first study discussed suggests a direct correlation between FAP cells and muscle repair. Up-regulation of certain growth factors such as VEGF gives a possible



mechanism of action for FAP cells and how FAP plays a role in **cell differentiation** and **angiogenesis**. However, it is noted that the radiotherapy used to inflict injury may have mainly caused damage to the vasculature of the area which also explains why certain results were obtained. (3)

The second study points out another direct correlation between the trafficking of FAP cells and the muscle regeneration process. The data reveals that adipose tissue serves as a source of cells, including FAP cells and growth factors, that support **muscle healing** (4). This highlights an unsuspected association between muscle and fat.

Further studies, however, will be needed to address several **challenges** before FAP can be used for muscle repair therapy. The **mechanism** of its restorative properties needs to be identified and fully understood. Furthermore, autologous transplantation and the mode of therapeutic delivery need to be explored. Although the efficacy and true potentials of using FAP cells for skeletal muscle repair are yet to be defined, the clinical trials that have been completed so far show tremendous **potential**.

METHODOLOGICAL CHALLENGES OF RANDOMIZED CONTROL TRIALS OF OSTEOPATHY AND OTHER MANUAL THERAPY

EMILY TENNISON, L.Ac

Traditional methodological approaches to randomized control trials pose many challenges to osteopathy and other manual therapies. Challenges faced by research investigators include, blinding, randomization, control group or sham treatments, allocation concealment, sample size, study length, and follow-up. Manual therapy does not fit the traditional design structure of double-blind randomized control trials leading to design and study execution issues.

Ideally, in research, the placebo treatment mimics the intervention, thus allowing for allocation concealment and blinding. In double blind randomized control trials, the investigator delivering treatment and the participant are both blinded; however the success of osteopathy and other manual therapies rely heavily on training and experience of the practitioner, rendering it impossible to blind the practitioner and challenging to blind the participant. A systematic review of 53 manual therapy trials showed that a large number of trials did not accurately blind therapists or did not include data on blinding of research personnel and struggled to accurately conceal allocation of participants into treatment and sham groups.

Manual therapies, such as high velocity, low amplitude (HVLA) techniques, myofascial release, massage therapy, and acupuncture, cannot be performed without engaging in direct physical contact with the patient and requires anywhere from nine months of training in massage therapy to seven years for osteopathy. An untrained investigator does not possess the skill or sensitivity necessary to perform the intervention treatment and therefore cannot be blinded. It may also become apparent to the study participant that they are receiving the therapeutic treatment, or the sham treatment based on the nature of manual therapy or the quality or style of the treatment. Variations in treatment style, skill level, and technique may exist between practitioners leading to incomparable and unreliable results, further necessitating the need to require training of the intervention technique within the study itself. It can also be argued that a therapeutic environment and patient-physician rapport can affect the outcome of treatment in manual therapies, which is difficult to reproduce in a clinical trial setting. It is difficult to apply sham manual therapy as the participant may still receive therapeutic benefit due to the physiological response to touch. It should also be noted that many different styles of manual therapy derive benefit from differing depth and pressure of touch or distal treatments that may affect areas of the body other than the area where the participant is receiving treatment. Thus, a sham treatment that deviates in pressure or treatment area may still deliver a therapeutic result, even from unskilled and untrained individuals performing the sham treatment.

Sham or placebo groups in manual therapy research tend to either provide a simulation technique that is modified or compare the intervention treatment to a treatment using a “detuned machine.” For example, many high velocity, low amplitude studies utilized a simulation of the treatment but without the rapid movement or thrust, or another method is to use a detuned laser or ultrasound machine on the control group instead of the high velocity low amplitude treatment. Another style of sham treatment is one in which the sham does not alter the objective measurements utilized in the study such as blood pressure or heart rate.

One methodological approach used as an alternative to sham treatment is to create a no-treatment group, either a group that receives no treatment, a group that only receives the current standard treatment, or a group that is put on a “waiting list” and is contacted in later stages. Some studies administered treatment under general anesthesia, creating a sham group that did not receive treatment but was told afterward that they had received treatment. However, there is increased risk of co-interventions or concomitant care and recidivism in participants who may feel like treatment is ineffective, especially within the sham group.

We have historically defined placebo treatment as a dichotomy of either inactive vs active or ineffective vs. effective treatment and that sham treatments mimic the intervention. A more effective dichotomy might be non-specific vs. specific. Where specific refers to the specific modality that is the intervention treatment. Under this definition the placebo does not have to lack a physiological effect but should not produce the effect of interest from the intervention. This would also help solve the issue of “mimicking the intervention.” However, the designers of the study would have to elucidate the specific characteristics of the technique, ensure uniformity in timing, and differentiate these factors from the sham treatment.

The physiological mechanisms of manual therapies are not fully elucidated, and this poses many challenges to measuring objective quantifiable physiological changes in the body and designing a sham treatment that closely mimics the intervention but does not elicit the same physiological mechanism or effects. In pharmaceutical trials, the sham group may receive a pill that is the exact size, shape, and color as the intervention group; however, it is very difficult to create a sham treatment in manual therapy that mimics the intervention but differs enough to be considered sham. It is also problematic that the underlying physiological mechanisms of manual therapies are not well understood or elucidated, making it difficult to choose a sham treatment that does not elicit the same attributions as the intervention. Manual therapy studies, especially those involving specific tissue manipulation often do not show a significant difference between the intervention and sham, thus proposing that the intervention is not more effective than the sham. A possible explanation of this outcome is that the sham treatment is too similar to the intervention and is eliciting the same physiological attributions.

Manual therapy does not rely on a single or specific mechanism of action like many pharmaceutical drugs. Touch elicits the response of multiple integrated body systems simultaneously, making it impossible to control for physiological variables. Our limited understanding of these variables and how they interact compound complications in creating a control group that mimics treatment but does not elicit the same physiological variables. It involves close intimate contact with the patient and may be affected by rapport and other psychological factors such as trust or patient comfort. Physiological objective findings are limited by the technology and current innovation, as well as a lack of elucidation of the mechanism of action of manual therapies and understanding of the physiological changes that reflect patient subjective experience. These factors combined with differences in the application and style of manual techniques prevent widespread use of a standardized sham treatment.

It is also important to consider the role of the placebo effect and response in sham treatments. Placebo response is commonly considered a neurobiological and psychological response to the sham treatment. The number of studies and trials researching placebo response has greatly increased over the course of the last ten years, including placebo response as a potential treatment source. Our limited understanding of the physiological factors that precipitate placebo responses present many of the same challenges presented with designing an effective sham treatment in manual therapy clinical trials. Patient reported outcome surveys are a standard and widely utilized method for collecting data on the effectiveness of the intervention and reporting adverse events experienced during the trial and/or afterward. Patient reported outcomes are sensitive to placebo effect and become even more sensitive if the participant is not blinded. Manual therapy often relies on this style of reporting due to the ease of use and versatility; however, participants may engage in response bias and report improvements that did not occur. Outcomes may be hard to measure due to the multifactorial nature of pathologies traditionally treated by manual therapy, such as pain or the perception of pain. Pain is affected by structural injury, emotional or psychological state, such as depression, and genetic predisposition or possibly combinations of these and other factors, which may lead to differing outcomes. Standardization and a global definition among trials of outcome measures that may constitute a statistically significant improvement in pain does not exist. Two separate trials testing the efficacy of a manual therapy treatment may have completely different definitions of what constitutes pain and what change in pain is significant and therefore are incomparable.

It may be difficult or costly to measure physiological changes experienced during and after treatment. Peripheral blood flow, cardiac activity (ECG), regional blood flow, electromyographic activity, grip strength, blood oxygenation, intracranial blood oxygen level, electroencephalogram (EEG), nerve conduction velocity, and structural changes in tissue are some of the physiological changes we can measure before and after manual therapy trials to generate quantifiable data and deepen our understanding of the physiological response generated by manual therapy techniques. However, many of these measurements require specialized equipment and possible partnership with bioengineers. These physiological measurements must be appropriate or correlated responses to the intervention treatment.

While it is difficult to effectively test many manual therapies under the framework offered by double-blind clinical trials, it is critical to continue working to develop better testing methodologies. These techniques demonstrate high patient preference as well as continuing to offer an alternative to more conventional pharmaceutical interventions. While it might be easy to dismiss manual therapies due to what could be perceived as weak supporting evidence, it is instead important for providers of manual therapy to actively engage in the process of developing novel methods to research for these therapies that can begin to bridge the gap between anecdote and robust clinical data.

ORTHOBIOLOGIC INJECTIONS IN CLINICAL PRACTICE

DELANEY TYL, ATC, LAT **& ED SMITH,** PA-C

I was immersed in the world of orthopedics and biologics in 2016 when I was an undergrad and working under Dr. Jeffrey Watson and Ed Smith, PA-C. Over just 7 years, the field of orthobiologics has exploded and continues to advance very quickly. A brief definition of biologics: cells, blood components, and other natural substances that harness the body's ability to promote healing and decrease inflammation. Orthobiologics are those that are used in the field of orthopedics for a variety of musculoskeletal injuries, such as tendinitis but the most prominent being osteoarthritis.

Osteoarthritis is a degenerative disease that causes a progressive, and as of right now, irreversible loss of cartilage. This disease affects all races, both men and women and aging populations. However, patients as young as 40 years old can have severe osteoarthritis. The 4 cardinal signs on radiographs that define osteoarthritis are decreased joint space, subchondral cyst formation, subchondral sclerosis, and osteophyte formation. The signs and symptoms include pain with activities, pain that wakes them up at night, joint swelling, and decreased overall function and daily activities. There is no cure or replacement for damaged cartilage at this point. All we have are nonsurgical treatment options to manage pain and inflammation, like cortisone injections and NSAIDs, and surgery for a total joint replacement. Orthobiologics is the promising middle ground that has the potential to repair damaged cartilage with continued research.

In 2016 when I first stepped foot into the field, the most widely available biologic was hyaluronic acid (HA) injections. These are still widely used to treat mild to moderate osteoarthritis but have started to take a back seat as more advanced orthobiologics have been developed. Soon after HA, we started performing platelet-rich plasma (PRP) injections for various orthopedic injuries. PRP is a type of biologic but is not considered a true mesenchymal stem cell. It consists of a high concentration of platelets and growth factors and a variable amount of white blood cells to enhance the body's natural healing. The varying amount of white blood cells results in both leuko-rich and leuko-poor PRPs. Which PRP to use is determined based on the injury being treated and the physician's preference. The effect of PRP is mostly related to the acceleration of the healing process but does not provide improvements in the final structure and properties of repaired tendons. This is a very simple procedure that requires drawing the patient's blood, separating the components via a centrifuge, and injecting the final PRP into the injured area. "Right now we are using PRP injections for non-surgical treatment of tendinitis but we can also use leuko-poor PRPs to treat mild osteoarthritis. Since these are not true mesenchymal stem cells they may require a series of injections. We have also started using PRP injections to enhance surgical procedures like ACL reconstructions and tendon repairs by trying to accelerate healing and reduce postoperative inflammation" (Ed Smith, PA-C, personal communication, April 13th, 2023).

Cellular -based therapies started to make their way into

practice around 2017. Cellular-based therapies contain the same growth factors as PRP but also contain a small number of mesenchymal stem cells (MSCs). You can obtain autologous versions of these therapies from your own harvested adipose tissue or bone marrow aspirate concentrate (BMAC) or from allograft donors such as amniotic products. True amniotic products are not used in clinical practice as they are currently illegal in the United States. The technology in making these superior types of injections has evolved drastically since 2017. Initially, both adipose-derived products and BMAC required going to the operating room for the harvesting, filtering of contents, and injection. These procedures transitioned from a surgery that required the patient to take a lot of time off of work and cost a significant amount of money, to a simple in-office procedure with local anesthetic about 4 years ago for adipose-derived products and 2 years ago for BMAC. The number of MSCs per milliliter of concentrate obtained from adipose tissue and bone marrow aspirate is essentially the same after the products have been filtered. The only difference is that a larger amount of adipose tissue is required to obtain the same concentration of MSCs when compared to the BMAC. Cellular-based therapies have been reported to improve functional outcomes and result in more durable, quality tissue. "The use of adipose tissue aspirate is more popular in our clinic because it is significantly less painful for the patient and although uncommon, if an infection were to occur, we are not introducing it directly into the bone marrow. We have seen patients do really well with these injections and I cannot think of a patient who has come back for a repeat injection in the same joint. Plenty of them come back for a stem cell injection in a different joint though." (Ed Smith, PA-C, personal communication, April 13th, 2023). Increasing ease of harvesting orthobiologics in the office has allowed physicians to provide patients with a variety of treatment options. With proper patient education and guidance from their physician, patients can participate in their treatment and choose which product is best for their lifestyle and their condition. "I believe stem cells should be the first line of treatment for certain musculoskeletal disorders over steroids but because insurances do not cover it; it is not a treatment option at all for most patients." (Ed Smith, PA-C, personal communication April 13th, 2023). The ultimate goal in developing these products is to get patients moving pain-free sooner and without surgery if possible. We are still a long way off from producing a product that truly regenerates lost cartilage but at the rate that this field has been advancing in just the past 7 years, the solution may be right around the corner.

THE RISE OF ARTIFICIAL INTELLIGENCE IN MEDICAL IMAGING

HENRY ASH

Artificial intelligence (AI) refers to intricate computer systems which can perform complex tasks that would normally require human intelligence (e.g., language and image processing, speech recognition, etc.). The field has had significant growth in the last few years due to increased computational power, machine learning approaches, such as deep learning, and increased **data availability** for training.[1] The general public has also become more accustomed to AI, with AI-powered **chatbots** and **virtual assistants** becoming increasingly common in customer service and with free-to-use platforms like ChatGPT entering everyday life. Far from being only effective in chat rooms, AI has proven itself useful in the healthcare industry and may even be revolutionizing the interpretation of medical imaging.

AI has begun to help clinicians interpret medical images such as conventional radiographs (X-rays), CT scans, and MRIs more accurately, efficiently, and effectively, at speeds otherwise beyond human capabilities. Traditionally, the interpretation of imaging is a **time-consuming procedure** that requires a radiologist or trained clinician. For radiologists, AI has the potential to help triage, automate, and provide accurate interpretation of images. Using image-analyzing software, an AI-based medical imaging system can identify abnormalities, such as **fractures or tumors**. AI systems excel at providing quantitative rather than qualitative analyses.[3] This capability can give radiologists more time to focus on complex cases and provide more accurate diagnoses.

The history of automating image analysis can be traced back as far as 1963 when Lodwick et al described a computer system for analyzing lung cancer prognosis.[1,2] Today, some of the most prevalent approaches to AI systems are rules-based approaches and machine/deep learning.[1,3] To build these programs, the systems need a large data pool to train on. In the case of an AI designed to analyze X-rays, multiple X-rays are needed. *ChestX-ray*14 is a publicly available set of over 100,000 radiographs released by the National Institutes of Health Clinical Center, which has significantly aided the development of AI image-analysis systems. Several AI image-analysis products have been approved by the United States Food and Drug Administration, as well as approved for European use.[1]

X-rays are the highest volume type of imaging in healthcare worldwide and thus have been the largest focus in AI image-analysis systems. Early use of these systems was for the detection of lung nodules, but recently their application has expanded to pathologies such as tuberculosis, pneumothorax, and pleural effusion screening. AI image-analysis systems have the ability to 'flag' an area on which the clinician should focus.[1] In other image modalities too, has AI been making headway. Although the quality of ultrasound imaging is largely user-dependent, AI has excelled at quantitative analysis of images in areas such as the thyroid, breast, and musculoskeletal system.[4]

With recent explosive growth of AI, the healthcare imaging industry has seen massive developments. The highest volume burden for imaging is the conventional radiograph, and thus AI image-analysis systems have been most focused on developing detection of these images first. However, AI image-analysis systems are also being developed for Ultrasound and other imaging modalities as these systems can provide a high degree of quantitative analysis. These systems have been shown to be diagnostically effective, and are approved for use in some countries, but more research needs to be done as they continue to become more mainstream.

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Thank you to Uriel UC, Dominik Hofbauer, and National Cancer Institute for images used in this issue from Unsplash.